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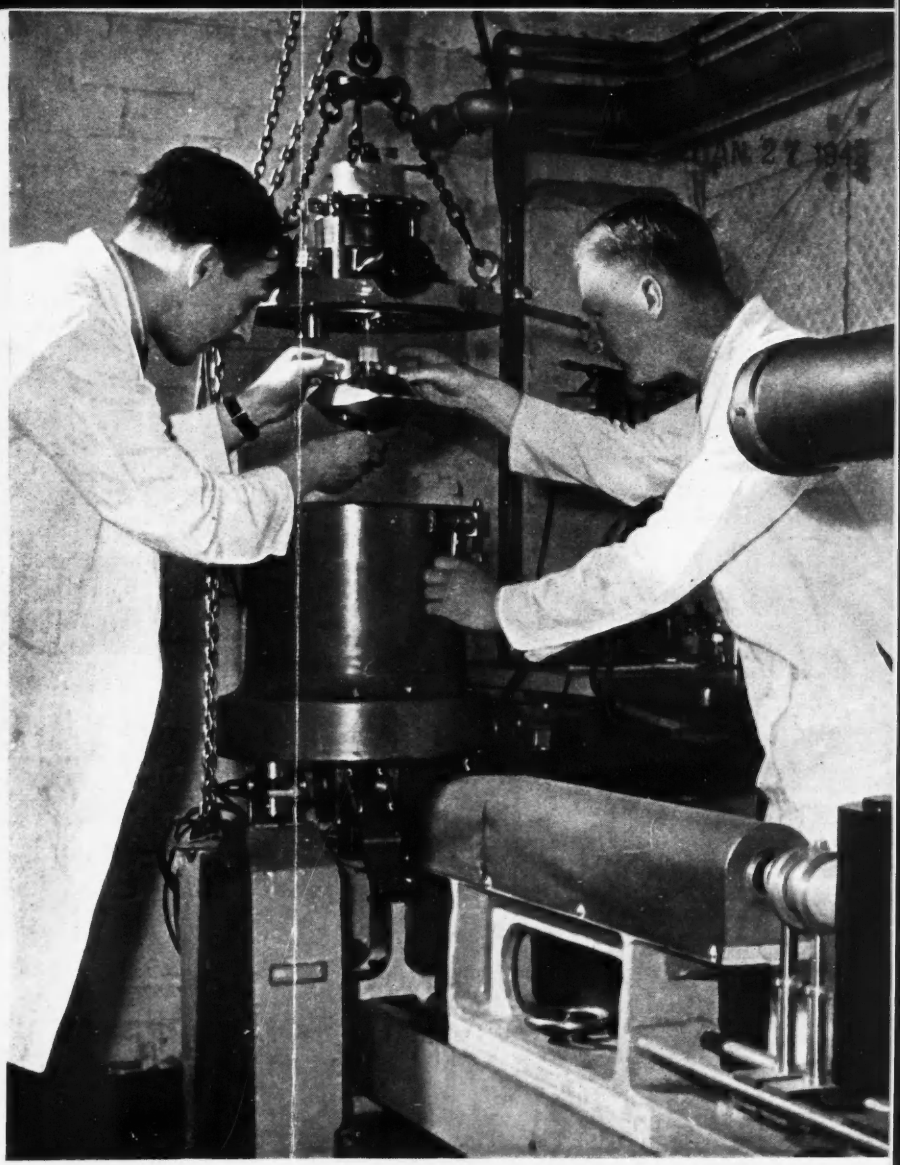

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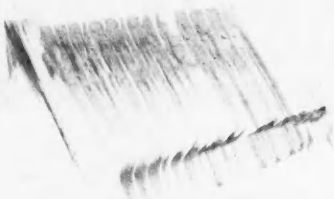

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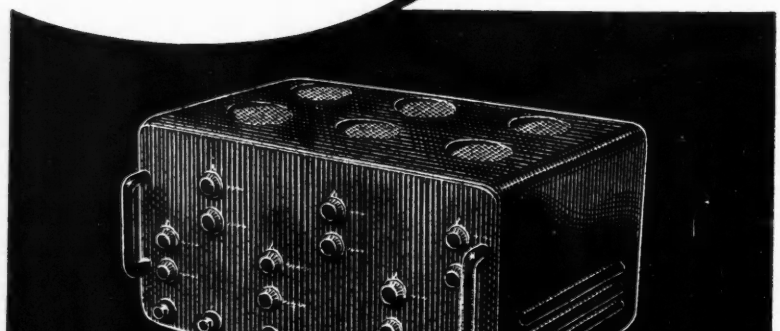

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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

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The Progress of Science

Patulin against Cancer

PATULIN, a water soluble antibiotic, was first discovered as a metabolic product of *Aspergillus clavatus* and in 1942 also isolated from *Pennicillium claviforme* by Chain, Florey and Jennings. A year later it was rediscovered by Raistrick and his colleagues in cultures of *Pennicillium patulum*. It was claimed that patulin was beneficial in the treatment of the common cold; but neither Stuart-Harris, Francis and Stanfeld, nor a committee of the Medical Research Council who investigated this question could confirm this statement.

In 1944, Chain, Florey and Jennings found that patulin was more toxic to leucocytes and tissues than to bacteria. About the same time and independently from the British team some German research workers were studying the properties of patulin. Foremost among them were Dr. Hildegard Vollmar of the Chemotherapeutic Research Institute, Frankfurt, and Dr. Moll of Messrs. E. Merck in Darmstadt. They were both killed in an air raid on Darmstadt in December 1944, but the result of their work has recently been published in a German scientific journal.

Dr. Vollmar examined the way in which certain bacteria and their metabolic products influenced the growth of cancerous tissues, and she suspected a certain retarding effect on their development. In the course of her investigations she experimented also with patulin, which she applied to:

(*a*) skin tissue (cornea of rabbits),
(*b*) white blood cells,
(*c*) malignant skin tissues.

The results of her experiments make fascinating reading. In collaboration with Dr. Moll, she found that normal skin tissue (in culture) after the addition of patulin in a concentration of 1 : 50,000 was stimulated to an extraordinarily rapid growth, which was even more marked when a more concentrated Patulin solution (1 : 25,000) was used. But if the patulin solution was further concentrated (1 : 10,000) a growth-inhibiting effect was noticed, leading to a complete stoppage of growth when a solution of 1 : 5000 was applied.

The same stimulating effect of dilute patulin and the same paralysing effect of more concentrated solutions was also observed in connexion with white blood cells. Their mobility was increased when a solution of 1 : 50,000 was added and further stimulated with a solution of 1 : 25,000. The paralysing effect became apparent when a concentration of 1 : 5000 was used and a solution of 1 : 1000 led to complete immobility of the tested leucocytes.

The effect of very dilute solutions of patulin on normal skin tissues and on white blood cells indicate its use for the more rapid healing of wounds.

Even more interesting were her experiments with malignant skin tissues. She proved that dilute solutions of patulin, which stimulated the growth of normal tissue cultures, acted as an inhibiting agent when applied to a culture of cancerous tissue. After the additions of these solutions (1 : 50,000 and 1 : 25,000) the malignant tissues increased by only a very few cells which appeared to be degenerate.

Dr. Vollmar summarises her experiments thus:

(*a*) the growth of normal skin tissues is accelerated by the addition of dilute solutions of patulin (1 : 50,000 and 1 : 25,000).
(*b*) the mobility of white blood cells increases proportionately under the impact of the same solutions, whilst
(*c*) the growth of malignant tissues in culture were retarded after the application of these patulin solutions.

Dr. Vollmar was puzzled by this seemingly dual and contradictory effect of Patulin and planned further investigations which might have shed some light on the problem; she did not live to carry them out. This work clearly suggests that patulin should be thoroughly re-investigated.

How Insecticides Act

THE available facts indicate that insecticide activity is due to widespread interference with the biochemical processes normally found within the insect body. Precise details of the interference mechanisms are wanting. However, there are a number of promising clues to the mode of action of insecticides.

Tissue degeneration frequently accompanies toxin action. Dissolution of muscle tissue in which a red coloration may develop, sloughing of the lining of the gut, and extensive blood cell destruction are typical of one aspect of arsenic action. Pyrethrum, Gammexane, DDT, and others cause vacuolation—the appearance of minute bubbles—in brain and nerve tracts. Slight changes in the fine structure of muscle can also be detected. Usually these changes occur soon after death, so that some other explanation of toxicity must be sought.

Often an inert compound is formed between the toxin and one of the substances taking part in vital processes. Hydrogen cyanide gas combines with the enzyme which conveys oxygen dissolved in the body fluids, to the seat of cellular respiration. The new compound, whilst it combines rapidly with oxygen, is unable to hand on this gas to the next stage in the respiration process. Consequently, although the insect is surrounded by sufficient oxygen for its needs the tissues will be starved of the gas, since they cannot absorb it. Arsenicals have a great affinity for the active sulphur groups of many proteins. Glutathione and 'pyruvic oxidase' are naturally occurring substances rich in the active sulphur group, and they play an important role in general metabolism and respiration. Fink in 1927 showed that insects poisoned by arsenicals showed a parallel diminution in both respiratory intensity and in glutathione. 'Lewisite', also an arsenical, is thought to inactivate pyruvic oxidase. Further evidence of arsenic activity is to be found from the fact that mammals which have, over a long period of time, acquired a lethal dose, deposit the toxin in the hair, which is largely composed of a sulphur-rich protein, keratin, with which the arsenic combines.

Digestive enzymes are similarly blocked by inhibitors. The following compounds accomplish just this, in the gut of insects. Mitin FF, a product of the Geigy organisation, prevents the digestion of keratin by the clothes moth maggot; the toxin acts directly upon the enzyme, and has been used to prevent the ravages of the clothes moth. Compound 2, a sulphonamide, acts upon enzymes which digest plant carbohydrate in the gut of the Colorado beetle larvae. In these instances death ensues as the result of starvation. Other cases remain unconfirmed. The molecule of gammexane has a shape similar to that of meso-inositol which is important in growth promotion. Gammexane was found to prevent growth in yeast cultures. The cultures resumed growth upon the addition of meso-inositol. Unfortunately, injected meso-inositol did not alleviate the symptoms in gammexane-poisoned cockroaches. A similarity in length exists between the molecules of DDT and a naturally occurring substance, cholesterol, both these substances accumulate in the suprarenal glands of mammals. The cholesterol content of the suprarenals determines the level of blood sugars; when much cholesterol is present in these glands the blood sugar rises. During the initial stages of DDT poisoning a great rise in blood sugar occurs. It is tempting to speculate whether this blood sugar increase may not be due to the artificially high 'cholesterol', i.e., normal cholesterol plus DDT, content of the suprarenals.

A number of toxins, among them DDT, gammexane, lethane, pyrethrum produce various dysfunctions in the segmental nerve tissue. Each body segment contains a pair of ganglia with motor and sensory nerves, and these elements are sufficient to show the typical response to these toxins. Restlessness, muscular activity, lack of limb co-ordination, and helpless limb twitching are the progressive symptoms in this group. The motor nerves are thrown into spontaneous multiple discharge. These discharges are probably due to a derangement of ionic balance between the nerve sheath and the conducting strand; a similar response is given by the fibre in the presence of excess magnesium or calcium ions. The great nervous stimulation results in observable muscle activity. Animals which have died from these poisons are found to have low sugar reserves, so it is fairly safe to conclude that death has ensued as a result of exhaustion of the tissues. Where the animal is anaesthetised whilst suffering from these poisons, muscle action is prevented and recovery results. In this instance no exhaustion is noted. As a second stage in the action of these toxins the nerve fibre ceases to conduct any impulse, but DDT does not produce this second stage until late after administration. By contrast pyrethrum causes early nerve block, and this may be the reason for the large number of animals which recover from the effects of this toxin. Nicotine causes blockage at the nerve endings within the ganglia.

Immunity to insecticides is of common occurrence. Antitoxins are not formed by the insect tissues in the same way that the mammal achieves immunity to virus or bacterial disease. Instead, immunity in insects is due to some peculiarity of the animal's physiology. Many insects obtain immunity to derris extract because of the stoutness of their waxy cuticle. Such insects when put to run upon emery cloth abrade this wax, and after such a preliminary treatment the insects show susceptibility to the toxic extract. This wax layer renders the insect especially vulnerable to fat soluble insecticides. DDT is a good example of this, since superficial application of this poison to insects having waxy or non-waxy cuticles results in greater toxicity to the former type. Both types are equally susceptible to intrabdominal injection.

Resistance to arsenic poisoning in leaf-chewing caterpillars depends upon the sensitivity of the gut muscles. In resistant species regurgitation rapidly occurs when arsenic has been taken into the gut. Susceptible species do not regurgitate until large amounts of poison have been consumed, and by this time much of the toxin will have diffused to the tissues. Again both types are equally susceptible to intrabdominal injections of the poison.

The citrus growers of California recognise several areas where the scale insect is difficult to kill with cyanide during routine orchard fumigations. In this case and with other cyanide-resistant insects, the tissues react rapidly to the poison. General collapse of the insect occurs before a lethal dose of the toxin has been acquired, but non-resistant species have not this ability of early collapse.

Future progress in understanding insecticide action will rest only in a more complete investigation of insect physiology. This aspect of the work is still in its infancy. The examples here quoted indicate that when more is known of the structure and functions of biochemical substances, it may be possible to 'tailor' toxin molecules so as to block enzymes. Alternatively the toxin molecule can replace naturally occurring substances in vital processes.

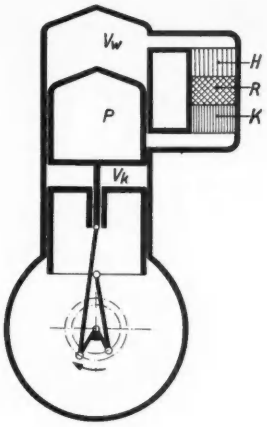


FIG. 1.

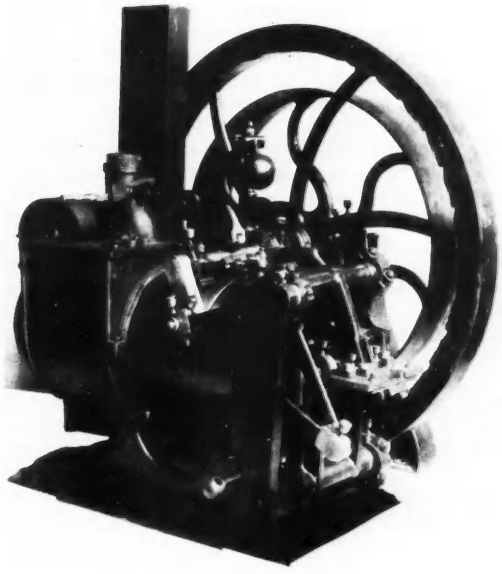
The Hot Air Engine

EARLY in the last century a simple type of engine was invented by two Scottish brothers named Stirling, which for a time was thought to be a serious rival to the steam engine, then in its infancy. The basic principle of the invention was that more work is needed to compress a given volume of gas if it is hot than if it is cold. Consequently, if a volume of gas is compressed at a low temperature, heated, and then allowed to expand against a piston, more work is gained during this expansion than is used during the low-temperature compression. The principle was applied by circulating air between a cold space, usually water-cooled, in which it is compressed, and a hot space, heated externally by a fire, in which it expands before returning to the cold space. In spite of much effort, the early hot air engines were never successful. Their efficiency was low and, for the power developed, they were very heavy. With the subsequent rapid development of the steam engine, and later of the internal combustion engine, the hot air engine was completely neglected by the mechanical engineer, and until recently its only uses were in driving toys and small laboratory pumps.

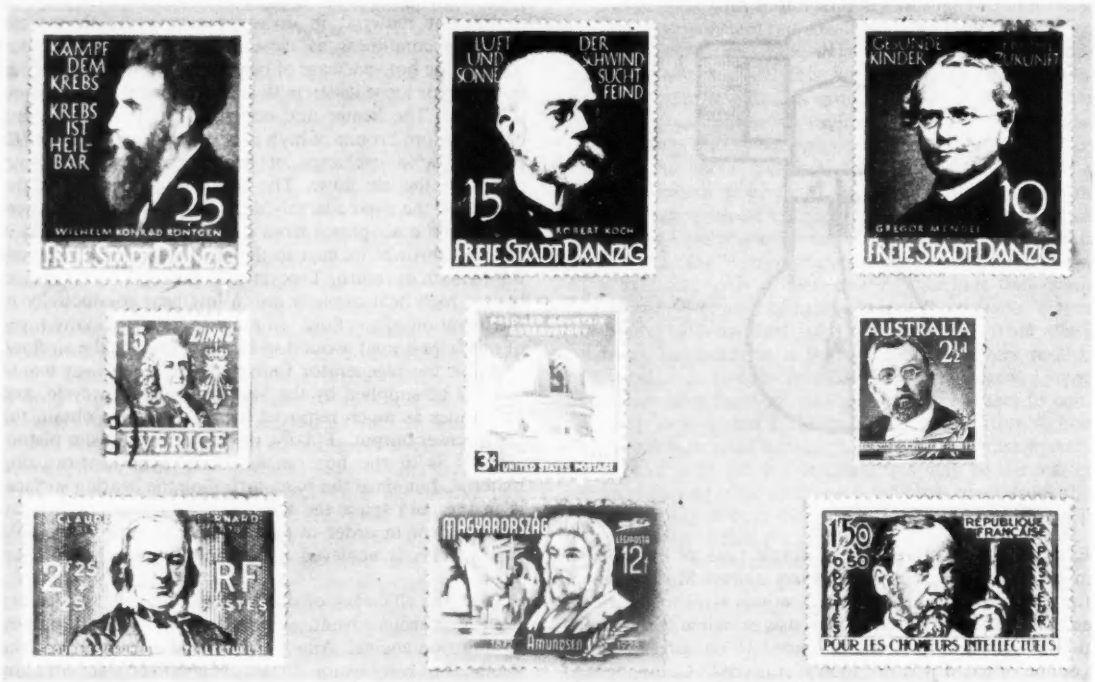
Theoretically, however, the cyclic process involved is one of the most efficient methods of converting the thermal energy of a hot gas into mechanical energy. About twelve years ago engineers in the Philip's Research Laboratory at Eindhoven began to re-examine the whole problem of the design and construction of the hot air engine. So promising were the early results that the work was continued in secret during the German occupation, and they can now construct engines having efficiencies comparable with those of internal combustion engines but which are considerably lighter for the same horse-power. The essential simplicity of the hot air engine makes it cheaper to build and gives it great reliability.

Fig. 1 is a diagrammatic cross section of a single-cylinder version of the engine. The hot space *Vw* at the top receives heat from an external fuel burner (not shown) via the heater *H*. Air in this space is driven through the regenerator *R* and the cooler *K* into the cold space *Vk* by the transfer piston *P*. Each of these components is made from a different material in order to satisfy the theoretical optimum conditions as closely as possible. The outer walls of the hot space are of heat-resisting steel which does not creep or loose its strength at the temperatures involved (650° C.). The heater and cooler consists of radial fins of aluminium bronze of high heat conductivity in order to provide rapid exchange of heat with the air without impeding the air flow. The regenerator, on which the success of the engine largely depends, acts as a heat reservoir. As the air passes from the hot space to the cold it gives up most of its heat to the regenerator, and recovers this heat on its return. Theoretically the regenerator should have a high heat capacity and a low heat conductivity in the direction of gas flow. In practice a coil of many turns of thin wire is used, wound so as not to impede the air flow. Without the regenerator four times as much heat would have to be supplied by the heater during each cycle, and four times as much removed by the cooler to obtain the same power output. Finally, the cap of the transfer piston, since it is in the hot space, must be of heat-resisting material, but since the base, including the bearing surface, is in the cold space the thermal conductivity of the cap must be low in order to prevent loss of heat to the cold space. This is achieved by using thin nickel-chromium steel.

Once the efficiency of this type of engine is satisfactory it has numerous advantages over the conventional internal combustion engine. Any kind of fuel can be used and the products of combustion do not come into contact with any of the moving parts, so that there is no deposition of carbon, or corrosion inside the cylinder. No explosions occur, so



Ericsson's heat engine. *(Crown copyright)*



that the forces in the connecting rods are very much smaller than in the i.c. engine, and the life of the bearings is consequently very much longer. Frictional losses are very small owing to the absence of any valve mechanism. No electrical equipment such as ignition coils or sparking plugs is required. On the other hand, instant starting is not possible with the present simple design since the hot space must be warmed up to the working temperature before the full power output can be obtained.

It is too soon to attempt to predict the field in which this development will find its chief application, but there can be no doubt that it marks an important step forward in the history of prime movers.

Science on Postage Stamps

THE story has been told of an enterprising salesman who toured the backwoods of America offering a first-class engraving of the President for an advance payment of 50 cents. When the engraving eventually arrived, it proved to be a 2-cent postage stamp. In these days of growing interest in science and its history, this exponent of private enterprise might have decided to specialise in engravings of great scientists.

Benjamin Franklin, famed for his electrical researches, appeared on the first United States stamp of 1847, and on many occasions since. But one suspects that he was honoured as a statesman rather than as a scientist. In fact, before the 1920's hardly a single scientist seems to have been honoured, as a scientist, by the issue of a special stamp. Captain Cook (New South Wales, 1888, and later elsewhere) might appear to be an exception, but again one suspects that he is celebrated as an explorer, rather than for his work on scurvy. The only other exceptions are medical men or scientists whose real claim to fame lies in their political or literary activities.

In the 1920's scientists begin to crop up on stamps in significant numbers. Pasteur appeared in 1923 on a French issue, and Copernicus on a Polish one. In 1925 the Russians printed stamps with portraits of Lomonosov and Popov (a partial anticipator of radio); Berthelot, Boerhaave, Huygens, Lorentz and Volta also appeared on stamps in the twenties. In the thirties we find stamps with portraits of some two dozen scientists as well as many medical men; these include such names as Ampère, Aristotle, Claude Bernard, the Curies, Darwin, Galileo, Guericke, Linnaeus, Mendel, Mendeléef, Pasteur and Roentgen. The forties have so far added about twenty more scientists and nearly as many medicos. Inventors and technologists do less well, with only about eight issues since 1930.

Thus postage stamps reflect with remarkable faithfulness the growing interest of the last three decades in science. Before 1920, when a country looked for a great man to celebrate on its stamps, it invariably chose a politician or literary figure (who might by coincidence also be a scientist). But now it is realised that scientists have their own right to honour. There is another way in which stamps reflect a modern trend—the medical movement towards the creation of positive health, instead of mere cure of disease, is illustrated by increasing numbers of stamps bearing pictures of health resorts, child welfare, physical training and the like.

Post-offices have occasionally been surprisingly international in their choice of scientists. Thus the Curies have

been honoured on the stamps of Afghanistan, Cuba, France, Monaco and Panama. Indeed this is the only way that British scientists or medicos can ever have a place on any stamp at all. Sir Joseph Banks has been given a philatelic place by New Zealand, and Darwin by—of all countries—Ecuador. But the stamp album of the most enthusiastic collector must lack portraits of Newton, Harvey, Jenner, Faraday, Maxwell and a host of others.

Outside portraits, science is not often suitable for miniature illustration. There are occasional stamps with pictures of scientific institutions—like the U.S. one of the Smithsonian Institute in 1946—and rather more of hospitals and other medical institutions. But there is probably only one scientist in the lucky position that his main claim to fame can be printed on a postage stamp; he is Mendeléef, whose portrait the U.S.S.R. superimposed in 1934 on a miniature version of the periodic table.

Chronology by Carbon 14

For the past few decades radio-active substances have provided one of the most powerful methods of dating the past. The age of a rock containing uranium, thorium or actinium is estimated by measuring the quantities of their disintegration products and using the facts about their rates of disintegration. Hitherto, however, dating by methods depending on radio-activity has only been applicable to time spans ranging from some tens of millions of years upwards. For more recent chronology the methods have been tree-ring analysis (up to 1500 years back), varve analysis depending on counting the annual deposits laid down by glaciers (up to 10,000 or 15,000 years) and a method depending on a correlation between the ice ages and astronomical facts which allows dates to be fixed over the last few hundred thousand years. (These methods were described by Professor Zeuner in Discovery, vol. VII (1946), 104–12.)

There now seems to be a possibility that radio-activity determinations will help to solve some of the more recent chronological problems, in the range of 1000 to 30,000 years ago. This time the element involved is carbon 14, the radio-active isotope of carbon which was discovered by Ruben and Kamen in 1940.

If air is bombarded with neutrons, the chief effect is the production of carbon 14 from the carbon in the atmospheric carbon dioxide. Now cosmic rays impinging on the upper atmosphere produce about two neutrons per square centimetre per second. These neutrons in turn act on the carbon dioxide to yield carbon 14. At the same time carbon 14 already produced is disintegrating with a half life of about 5100 years. Since all this has been going on for a very long time, the production and disintegration processes must balance one another; and from that it is easy to calculate that there must be about 50 metric tons of radiocarbon on earth.

The radiocarbon, as it is produced, will quickly be combined to form carbon dioxide. Mixing with the ordinary carbon dioxide of the air, it will be assimilated by plants, and thence by animals. So that all the carbon in living matter will contain radiocarbon in the same proportion as it exists in the atmosphere. The dissolved carbonates in the sea also rapidly exchange carbon with the atmosphere, so that these, too, will contain radiocarbon in the same proportion. Adding all these together,

it can be calculated that the atmosphere, the sea, and living matter must all contain about one gram of radiocarbon in every million million grams of ordinary carbon.

But when a plant or animal dies, it will soon cease to exchange carbon with the air. The process of disintegration continues, but there is no addition of new radiocarbon, so that the proportion of the latter must continually decrease. Thus the proportion of radiocarbon in anything that was once alive will give a measure of how long it has been dead. If it contains half as much radiocarbon as does living matter, it has been dead about 5000 years; if a quarter as much, 10,000 years; and so on. Present methods allow the direct detection of radiocarbon diluted to the extent of about one part in a million million, i.e., to just the dilution that occurs in living bodies. But isotope enrichment processes allow the radiocarbon in any given sample to be concentrated some 250-fold, so that proportions of about 4 parts in a thousand million million can be detected. Thus, since the half life of radiocarbon is about 5100 years, it ought to be possible to use the method to estimate dates between about 1000 and 30,000 years ago—dates, that is, for anything that was alive within that period.

So far this method is only a proposal. It has already been verified that methane from sewage gas gives, at least within a factor of three, the proportion of radiocarbon to be expected in living matter, and that methane from mineral oil does not contain radiocarbon. Thus the theory is verified for the two extremes of the present and the very distant past. Its accuracy as a dating method is being tested against material of known date from Egypt.

World Health Organisation

THE effective beginning of the World Health Organisation dates from its Assembly in July, when it decided on its immediate plans and the organisation for carrying these out. The Organisation's mandate from the United Nations is "to act as the directing and co-ordinating authority on international health work". The interpretation to be put on these words was, however, the subject of considerable discussion. The United States delegation took the view that what was needed was an institution to help backward countries to create health services and bring them up to the level of the advanced countries. On the other hand, Great Britain and most of the European countries felt that the advanced nations should also be beneficiaries, so that the organisation should also deal with their problems, a difference which the conference resolved quite satisfactorily.

Most of the conference's decisions were unanimous, and not a little of the credit for this happy outcome goes to the elected president, Dr. Andrija Stampar, Rector of Zagreb University, who had, in the words of one delegate, an 'unanimity complex'.

The Assembly decided on the priorities of its work in the initial years. In the first group come malaria, tuberculosis, maternal and child welfare, nutrition and hygiene. Next there is public health, including the whole field of nursing. Third priority goes to 'parasitic' diseases (such as those due to parasitic worms), which trouble tropical and subtropical countries. Fourth on the list are the virus diseases, including influenza and poliomyelitis. The fifth place is assigned to mental health. And the sixth group includes the study of cancer, rheumatoid diseases, leprosy and undulant fever.

The methods to be used are very various. On some subjects international committees of experts will be appointed. In other cases the World Health Organisation will work chiefly by co-operation with other national and international bodies. There will be regional offices which will begin in a small way by collecting and distributing epidemiological information, and will later undertake local field work, such as the organisation and equipment of teams to attack malaria and tuberculosis.

The funds available to the Organisation amount to £1,250,000. True, it can, with the aid of luck and judgment, produce a disproportionately large effect by using its funds to co-ordinate existing organisations. But when all is said and done, £1,250,000 seems a small figure to spend on the world organisation for the fight for health.

International Book-token Scheme

SCIENTISTS in this country will soon be able to purchase books from "hard" currency countries under a U.N.E.S.C.O. book-token scheme just announced.

This scheme is devised to overcome foreign exchange difficulties and so enable educational and scientific institutions in "soft" currency countries to buy publications from "hard" currency countries. Purchases will be made in the national currency of the countries concerned and U.N.E.S.C.O. will supply the necessary dollars.

The plan will operate for an experimental period of one year and is limited to 150,000 dollars worth of book coupons which will be shared by eleven countries, including the United Kingdom. If it is successful, however, the scheme may be expanded to include all member states of U.N.E.S.C.O.

The coupons may be used to buy books on education, science and culture, the importation of which is prohibited by importing laws. They can also be used for subscriptions to periodicals, for the purchase of individual volumes or issues, and for the payment of photo copies. The coupons will be available in denominations ranging from 25 cents to 10 dollars.

Other countries where the coupons will be on sale are: China, Czechoslovakia, France, India and Poland. In addition, a limited free distribution, financed by U.N.E.S.C.O., will be made in Austria, China, Czechoslovakia, Greece, Hungary, Italy, the Philippines and Poland.

In each country special distributing bodies have been appointed which will be responsible for the sale of coupons and will also serve as information centres for questions relating to the scheme. In this country the scheme will be run by Book Tokens Ltd., and details of how it will operate are now under active consideration.

"Endeavour", "Science Progress" and "Discovery" worthily maintain our reputation in the field of popular exposition—Sir Robert Robinson in his presidential address to the Royal Society.

The Dead Hand on Discovery

C. D. DARLINGTON, D.Sc., F.R.S.

II.—THE THUMB OF OFFICE

Recapitulation

We have now seen that men, and the societies and institutions they set up, are all inclined to resist scientific discovery and its application—above all the application of the greatest of discoveries, those of scientific method. We resist these things more fiercely even than we resist social change. We resist them, not so much for the material loss, as for the mental disturbance we fear from them. As we get older, some of us acquire *wealth*; all of us acquire *belief*. And between belief and discovery there is an undying war.

This being so, the schools and universities which are governed so largely by the beliefs of the past, the beliefs of the dead—and in an old country like ours, the very distant dead—constitute an obstacle to adjusting our national lives to the conditions which discovery (partly their own discovery) is so rapidly changing. This obstacle is all the more dangerous because its worst effects can be seen only long after those responsible have themselves departed. It was only in 1940 that we reaped the harvest sown in an earlier age. The failure of our governments, and the civil service through which they operate, was determined when they, or even their fathers, went to school.

This failure is, in the first place, due to a lack of scientific and technical capacity in our administration and in our basic industries. There has been an insufficient demand in the past, so that there is now (not surprisingly) an insufficient supply of trained men. A hundred years' neglect has led to 100 years' decay. And it cannot be made good in 10 years. Nor can it be made good merely by a change in the ownership of industry. It can be made good only painfully and slowly by a revolution in theory and practice running right through our national life.

The long-term question of the universities I have dealt with. Let me now consider the short-term question of the men in office—politicians and civil servants.

Keeping Science Out

Scientists, it is admitted, possess the skill, and the knowledge, if not the wisdom, on which our government today largely depends. Ministers, therefore, sometimes feel that they must take scientific advice. But the scope and possibilities of scientific method and discovery are unknown to them. They naturally shrink from contact with the unknown or they resist its intrusion. And the resistance is most strenuous when it is happily allied with vested interests and with popular superstitions.

This alliance is achieved above all in the field of agriculture. For mere intention the Ministry of Education might dispute the palm for resistance to scientific innovation. But for actual achievement the Ministry of Agriculture undoubtedly has it. Whether it is in supporting the superstitions of stockbreeders, in blocking artificial insemination, in postponing the registration of varieties, in failing to discriminate between good and bad seed for the farmer: the Ministry offers its sure support to the practices of the past. The nation's shortage of bread, butter, meat and milk counts for nothing against this passion for the sovereign interests of private profit and public ignorance.

In making his policy, the Minister of Agriculture (to whatever party he belongs) ignores the existence of the large body of scientific investigators employed at great expense by his own department.* How then does the Minister arrive at a policy?. He turns to his non-scientific advisers, political or economic. Economists are particularly useful. They know everything about the past. From it they can construct the future, provided that they are allowed to disregard the element which they cannot predict, the element of scientific discovery. This they naturally do—and with reasonable safety where the Ministry of Agriculture is concerned. To be sure, advances abroad eventually disturb the peace at home. But the dead hand of the Ministry can usually keep them out for one—and sometimes, with skill and resolution, for two generations.

A higher degree of penetration of science has been reached in Ministries I can think of which were exposed to more wear and tear during the war. These are the departments which were compelled (after fierce resistance) to retreat to a safer position—where the front line would be defended by that powerful modern weapon the "Scientific Advisory Committee". How is this weapon constructed? The Minister appoints 20 men. Or rather his advisers do. They begin by appointing themselves—half a dozen of them—to provide a sound non-scientific foundation. Then they add half a dozen men who have had a scientific training long ago, but have now been made tame and tractable by an unblemished lifetime in the Civil Service. And, finally, they make up the number to a round score with administrative scientists, eminent men, who have, however, for a good while been prevented by just such committees from engaging in scientific research.

* The Ministry has even created a body to protect it from contact with these dangerous men, a body with the disarming name of the Agricultural Improvement Council.

With such a committee what Minister, or what government department, could fail to be happy? The Minister avoids meeting genuine scientists in the flesh; he avoids exercising his judgment or even revealing his lack of it; he avoids taking responsibility even in the fields where he most needs to take it. And the department avoids the peril, the fearful peril, of having to disturb its routine: no unforeseen scientific discoveries will probably be made, and certainly none will have to be applied.

So far everything is straightforward. When we come to a large field of activity like that of agricultural research in this country and consider it as a whole the position becomes more complex, more confused. To be sure, it is simplified by the Ministry of Agriculture's uniform resistance to the application of research. But agricultural research, it has been admitted, must be carried out, even if it is not made use of; and the task of administering it cannot be avoided. It was realised at the outset, of course, that, to have any success, research must be taken out of the hands of the Ministry and placed under an independent department, friendly to scientific research, and if possible, familiar with the principles and practices of scientific inquiry. The department chosen was the Privy Council which was to work through an Agricultural Research Council. But this strategy was only partly successful. All that was won was the right to *advise* the Ministry on the direction of a *part* of the work. In the struggle to extricate one part of the research from the Ministry, another part had had to be sacrificed to it. And the payment of the agricultural research worker, and of all his expenses and equipment, had to be left in the hands of the Ministry and of course of the Treasury; in the hands, that is, of departments responsible to no scientific authority, resisting all scientific interference, and hostile to all scientific discovery.

Moreover, as it turns out, key members of the Agricultural Research Council itself are indirectly nominated by the Ministry. And they are not themselves selected for their experience of agricultural research. For most of them, indeed, it is a secondary and temporary interest. And vital fields of inquiry such as those of economics, are excluded from their purview. Evidently, therefore, the independence of Civil Service control which is supposed to be enjoyed by agricultural research is still a constitutional fiction. Yet in attempting to achieve it all rational organisation, all unity of planning, and all efficiency of direction, have had to be abandoned.

The resulting system, which resembles some other forms of Civil Service organisation, may be likened to a simple conveyance—a donkey cart.

The reins are held by a big man appointed by the Minister of Agriculture. This man is totally blind, but he is prompted by a little man who sits at his elbow appointed by the Lord President of the Council (but paid by the Minister). There are a crowd of men running about at the back and working the powerful but unco-ordinated systems of brakes. They are put there by other Ministers and by various private interests. The men in charge never speak to one another. But they engage in endless dispute on trivial points by multilateral correspondence. The track is deeply rutted and much branched. But the turnings are marked with such labels as: ECONOMICS: Keep Off; COLONIES: Out of Bounds; ANIMAL HEALTH: No Admittance for Donkeys, and so on. Meanwhile the donkey, the scientific research worker, plods on—in blinkers. He, of course, is supposed to like the job for its own sake. And no one imagines that his opinions would be of any interest to the owners—who have in fact never set eyes on him.

The whole contraption, which strikes the casual observer as ill designed for its immediate purpose, is, however, largely successful in its greater object, that of shutting out the scientific discoverer from the chance of managing his own affairs, or applying his own discoveries, or his own talents, for the benefit of the nation.

It is not only Ministers who are saved trouble by hand-picked committees, interlocking and conflicting authorities, and other constitutional devices for blocking the application of scientific discovery. There is also the Civil Service. The higher Civil Service is a self-propagating organism. Each generation chooses its own successors. And, since like begets like, it chooses successors who shall be deeply imbued with a traditional and anti-scientific attitude. The Civil Service has to protect itself above all against the invasion of scientific method in its own field of operation. Committees, in origin packed, in purpose confined, and in authority crippled, serve this great end. They keep our leading men of science imprisoned in batches of a dozen in the attics and cellars of Whitehall and Pimlico for up to 30 hours a week, working at a job they are not paid to do—that of reading, in a bad light, harmless sheets of illegible mimeographed minutes.

The official fear of scientific discovery and the struggle which it calls forth in the peace departments may be seen diagrammatically from the history of the war departments in recent years.

During the 1914 war, faced with the continual technical superiority of the enemy, our military and naval authorities were driven (after having sacrificed the flower of our manhood) to admit certain innovations into their practice. Scientific methods from physics, chemistry and engineering were applied in limited fields. The danger existed that these methods might continue to infiltrate the armed forces in peacetime. Our admirals and generals therefore set themselves the task of unlearning the lessons of the first

war in preparation for the second. By 1940 they were almost perfectly restored to the happy ways which had brought us a tardy victory in the South African war 40 years earlier. And three years of almost uninterrupted defeat were necessary to secure their acceptance of radical scientific reform.

It is not a question of whether these things are personally discreditable to anyone. They show the power of resistance to innovation. They show the power our great peace departments are struggling to defend. They show what we get from inheriting public services from our illustrious grandparents. They show how heavy the dead hand of the past lies on our land.

A Select Committee

The peace departments have never been subjected to ordeal by fire. But they have been subjected to the pale twilight of parliamentary inquiry. There is a Select Committee on Estimates which published last year a report on the Expenditure on Research and Development. This document with its full transcription of the evidence is worth six shillings for the few who can perceive and enjoy the hidden beauty of the great triangular transaction between Parliament, the Civil Service, and the Official Scientist.

The committee wanted to find out whether the public money was in sufficient supply, and also whether it was being wisely spent. They interviewed the leading scientific representatives of the Civil Service. These included men of every degree of scientific eminence, from the highest down to those, representing the more cautious ministers, who were not scientists at all—who in fact belonged to the opposite camp.

Often the committee seemed to catch glimpses of the dead hand on discovery. Hastily they shrank from it. They found that Colonial research had been kept away from the supposedly supreme Tizard Committee. Prying inquiry had been avoided by a constitutional device. The committee asked no more. The committee naturally did not notice the omission of museums and botanic gardens: who would think that these bodies were ever intended for scientific research? They wondered why Forestry research was too shy to be shown. But they were not told.

The committee asked why the Ministry of Agriculture had to keep foot-and-mouth disease for itself, out of the hands of the Agricultural Research Council. They learnt it was just because this malady was so terribly infectious. So terribly infectious indeed that nobody knows how it infects. The committee were vaguely worried by the notion of a research station for the exclusive study of this one disease. And they were very clearly worried by the great sums that the Ministry of Agriculture has poured down the drain in its unique policy of the indiscriminate slaughter of all herds in which the disease appeared.

No one could tell the committee that at the same time that Pasteur discovered the principle of Infection Darwin discovered the principle of Selection. So that, by slaughtering cattle that are resistant to a disease, along with those that are susceptible, a government department may remove any possibility of a survival of the fittest. Indeed it may promise this nation, for the first time in history, an artificially irremediable disease.

It was fortunate that no such technical questions were pressed home. Naturally, evasion was often necessary. It was always successful. No cats were let out of bags. The evidence was entirely neat and consistent. The committee were satisfied on all great issues. The report was unanimous, and the matters gently raised were quietly dropped.

Three great evils arise from the non-scientific control or checking of scientific discovery. The first is the creation of hole-and-corner research. This is carried out on a large scale in this country. It varies in efficiency from 20% down to zero. It is carried out by small nationalistic or parochial organisations, the industrial research centres and sundry obscure and obscurantist government departments like the Forestry Commission. These bodies suffer from various diseases: some with a limited and defined purpose would terminate their existence if they were to solve their problems. Small wonder that, like university departments, they fight tooth-and-nail for the isolation which protects them alike from inquiry and from the danger of success. Others, again, have no defined purpose at all. Small wonder that bodies like the Natural History Museum and Kew Gardens which (both in London) reduplicate the same work, evade any new definition of what that work is, or what purpose it fulfils. Small wonder that the millers and the bakers must keep (at the public expense and with the approval of the D.S.I.R.) two independent, uncoordinated and overlapping research stations for the practical investigation of the same substance—wheat flour. This is planning with a vengeance.

There are also stations whose organisation may be quite unsuitable for the original purpose. It sometimes happens that, by a failure to classify a problem correctly in the first instance, an institute of rat catchers is set up—at great cost—for a job which involves hunting lions. Naturally, nothing thereafter will induce the rat catchers to admit that it is lions they are after. These are matters which can be judged only by someone with the technical means of distinguishing the two species.

The second great evil in the misdirection of scientific research results from the method of receiving what are called "problems" from the practical man. The problem is classified by its effect. But investigation classified by effects is bound to be superficial and defensive. To be fundamental and aggressive

investigations must be classified by causes. The classical examples of this on the physical side are the whole category of war researches. The great advances in the technique of war have not come from specialists trying to improve current techniques, but from outsiders introducing methods which surprise the specialist, just as they in turn surprise the enemy. Gunpowder was not invented by an archer or by an arrowsmith.

On the biological side, a corresponding position is taken by cancer research. The great advances in cancer research have come and will come from those who did not begin by attacking this special problem, or indeed any special problem, but from those who are concerned with fundamental problems. And a fundamental problem is one invisible to the practical man. It is invisible indeed to anybody except the discoverer.

Thus it is clear that the consequences of research need not be feared if institutions are set up for inquiry into a limited class of effects. Statesmen can be sure that an institute for the study of foot-and-mouth disease will not upset the principles of veterinary science, or the practices of the Ministry of Agriculture. They can be fairly confident that an institute for cancer research will not upset anybody's views on human heredity or democratic government. But unfortunately, in protecting themselves from what they regard as the worst consequences of fundamental inquiry, they also protect all of us against fundamental inquiry itself, and against its successful consequences, even in the limited field of interest. For unfortunately, as Nicolle has pointed out, the longer we are confronted with a limited problem the more incapable we become of solving it. The short cut which is the false cut inevitably becomes the beaten track of belief.

The third great evil of non-scientific control of scientific research is that it gives the lower grades of administration the means of venting their spleen on the research worker himself.

How do they do it?

Our present government is more aware—or more eloquently aware—than any predecessor of the importance of scientific research. They often tell us what they are doing to advance science for the nation's good. Accordingly, in 1945, they accepted new salary scales for research workers. These had been proposed by a committee in 1944 on the basis of costs in 1943. The principle was of course maintained that the man *without* any knowledge of science must always be paid more than the man *with* some knowledge. After all, the ignorant man is safe. He can be left in charge of important operations without any danger of unexpected results. Nevertheless, the decline in the value of scientific salaries was to be arrested. Increments were to be given of 10, 20 or even 30% above pre-war levels. This decision led to prolonged activity—or inactivity. The dead hand at the Treasury began to twitch. Discussions, compromises, calculations and miscalculations followed one another. Files accumulated. Minutes passed. And, since the Research Department of a Ministry could take nearly a year to answer a letter on this question, it is not surprising that years passed too. And still, in 1948, the game is not finished. Some government research workers have still received no communication and no increase of pay. Their salaries are overdue by two years. And their scale is out of date by five.

The position of the man retiring is even worse than that of the man at work. The lump sums, which retiring university and research station workers receive in lieu of pension, remain unchanged: and have therefore in effect been devalued since 1939 by 50%. Research workers who hear the eloquent praise of their services from the mouths of ministers therefore know how a grateful government is likely to reward their services when they are completed.

These are matters that the Select Committee on Estimates was too delicate to inquire into. And naturally no one told them. Scientific workers in Government employment thus find themselves in a poor and deteriorating economic position. Yet it is on this background that another Government policy is being superimposed, that of increasing the numbers of those engaged in scientific teaching, research and advisory service. What will be the effect? The men available for this work are limited in number. Their quality is variable. It is as variable as the quality of civil servants and politicians. The average quality is therefore going to get worse.

This is a grave matter, and for two reasons. In the first place, quality not only counts in scientific research: it is the *only* thing that counts. For what is not good is bad; and what is bad is a costly and dangerous liability. In the Civil Service it would be far better to pay a bad worker to stay at home rather than to fill a seat. In research, this principle is vital. Yet under non-scientific control, the very reverse principle operates. Mere numbers are a great asset, a source of prestige and of income, since numbers, degrees and titles are all that the non-scientific administrator can possibly understand.

We are bound now to ask ourselves how these matters are arranged in Soviet Russia. Can we escape there from the dead hand of the past? How do the communist politicians and the marxist administrators react to scientific discovery?

The Benefits of Bolshevism

In Soviet Russia the government is at least as keen on scientific research as ours is. It is also as ignorant of the processes by which scientific discoveries are made. And as ignorant of the distinction between

good and bad research, between repetition and innovation. The civil service, however, works under a new and brutal principle introduced by the revolution: incompetence is a ground for dismissal. Moreover, scientific and technical ignorance is no valid excuse for incompetence. Indeed, the highest civil servants can be liquidated for trying to use it. Science, or at least technology, therefore gets applied much more quickly than in England so far as the training exists for applying it.

Intercourse between scientists and members of the government is also easier than in our country (it was formerly much easier) but here the Soviet advantages end. The intercourse is of a strange character because the politician, being a marxist, is conscious of being at no disadvantage. He thinks he knows how discoveries are made. He therefore undertakes to correct and direct the scientist whose unguided inquiries would otherwise lead him off the true way of knowledge. Indeed the whole community (or rather party, for outside the communist party the community does not express itself), insofar as it knows more of the marxist dialectic than of scientific method, feels in a position to join in the hunt for orthodoxy when the hue and cry is raised. And it is often raised by the communist party, acting for the government.

Scientific discussions arising in this way are as free as in our country, with the easily overlooked difference that the losing side has been decided at the beginning, and is liquidated at the end. The dwindling remnant of serious scientists continue their inquiries on controversial matters with increasing circumspection. The majority, selected for their indifference to scientific principle, occupy themselves with justifying the ways of nature to the party in power; in other words, with the ordinary vices of bourgeois research, that is with window dressing combined with more or less of forgery and fraud.

These activities are perhaps useful in giving heart and hope to the less informed foreign admirers of the Soviet Union. They are less useful, however, when they deceive the Soviet Government itself: when, for example, that government is surprised to discover, as it did in July 1945, that its atomic physicists in their pursuit of new explosives had lagged so far behind their decadent and reactionary capitalist neighbours.

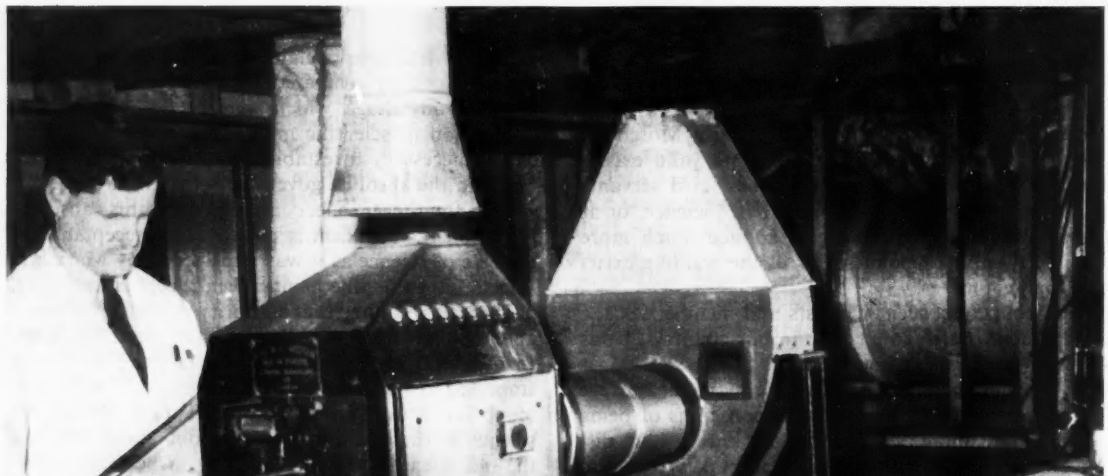
The action on the sciences of a communist revolution, it seems, we can now separate into short-term and long-term effects. Its short-term effect is that it suddenly liberates a nation from what the communists describe in their well-known phrase as the "reactionary obscurantism of the capitalist bourgeoisie"—what I have described as the hostility to discovery and its application in all established societies. It not only liberates the nation from the men of learning and the men in office who lay the dead hand on discovery; it also liberates industry from the dead hand that is laid on it with equal weight by capital and by labour. The enthusiasm generated by this release, and the material advantage which quickly follows the free application of scientific method, provide the surplus energy necessary to establish the communist revolution and the absolute government that follows it.

The long-term effect arises from this absolute government. Marxism is based on an acceptance of the rule of science as it was understood by Marx and Engels. But this rule having been accepted in theory, practice has required that authority should be reversed, and that science should accept the rule of marxism. In other words, that fundamental science should be stabilised at whatever point the party or the government find it expedient to do so. The supply of new science is thus dried up at the root and without it the old science itself withers away: it becomes scholastic and mystical. That is why, in Soviet-controlled countries (especially in the Russian zone of Germany and in Czechoslovakia), the biological sciences, with their grave political implications, are being pushed back as quickly as possible into the nineteenth century.

Thus the tremendous initial advantage of a marxist revolution is lost when it becomes established, and returns to the good old bourgeois habit of laying the dead hand on scientific discovery.

No doubt, the unpleasant character of the Soviet system of government, and its ultimate failure, will be put down to its having been based on a high esteem for scientific discovery. In fact, both its character and its failure will have been based on the subordination of scientific truth to political expediency: on the unexampled creation in a new state, of a dead hand, ready made, the embalmed and not quite authentic dead hand of Karl Marx.

What I have said in rapid generalisation of the dead hand on discovery may seem sad or even tragic. The tragedy, however, is not yet beyond our help or hope. Nowhere in the world, and at no time in history has such a rich harvest of discovery been reaped as in this country and at this time. And nowhere is the past, our own past, held in such well-justified respect. But we do not need to choose between the two. Rather we need to use our wits to save both. We need also to make a special study of this strange new science which our French friend called the Biology of Invention. Its principles are not to be discovered in the philosophies of the past, but in the facts and the follies which torment the world today. Merely uncovering these facts is enough to destroy many of them. Others require a purge of cant and humbug and the easy phrases of conformity. Others again even demand action, thoughtful, yet courageous and drastic. Are we, as a nation, still too secure, too contented, too prosperous, to think of that?



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Cotton Research

MAURICE GOLDSMITH, B.Sc. (Econ.)

THE British Cotton Industry Research Association was formed in 1919, after the first World War, when the cotton trade was passing through the then greatest boom in its history. "Everyone in England had the idea that research was a paying proposition; the cotton trade had money at hand which might have gone into excess profits duty, and some of it was deflected into the research organisation. I am only sorry now," wistfully added Sir Robert Pickard, F.R.S., then Director of BCIRA, in an address in 1936 to the Institute of Chemistry, "I am only sorry that more was not so deflected in that time of prosperity."

Whatever may have been the reasons for that statement then, they are out of place today: for the Shirley Institute —BCIRA is also known by this name because the estate of a large house and 14½ acres at Didsbury, Manchester, was bought from William Greenwood, M.P. for Stockport, at less than he had paid for it on condition that it was named after his only daughter, Shirley—is one of the most flourishing of the co-operative research organisations that the Department of Scientific and Industrial Research has fostered. It is financially stable: and—as the frequent references by Cabinet ministers and others testify—it is doing scientific work of national importance.

Yet the early difficulties were great, for—as Sir Robert told his fellow chemists—the Research Association "was an idea unfamiliar to the ordinary cotton man. The cotton industry is an old one, built up on inventions and by empirical rule of thumb methods, and to attempt to graft scientific organisation on to that was something entirely foreign to those brought up in the trade." That was why when the industry was first asked to submit its problems the response was extremely poor. Although there were over 1000 member firms, only one troubled to reply.

Despite the fact that they did not make much use of the Association, the members continued to pay their subscriptions. Thus, during the first five years of existence it was left free to tackle work of a fairly fundamental character. The studies then made of materials and processes proved of value as basic groundwork, and later put the Association in the position of being ahead of the times. The knowledge gained then made possible the practical applications, praise of which is becoming familiar to us today.

Financially, BCIRA has an annual income of about £200,000 which includes a Government grant based upon a pound for pound allowance, when the industry itself has subscribed a determined minimum. The minimum and maximum figures for Government grants are determined by negotiation on a five-yearly basis.

BCIRA is controlled by a Council made up of employers (leaders in the industry), employees (who include representatives of the trade unions), and DSIR. The

Council appoints a Director of Research, who has vested in him complete authority in relation to the laboratories. According to the articles, the director is the sole repository of the knowledge gained, but he must communicate the results of research simultaneously to all members. That is why he is chairman of all the technical sub-committees.

The Council functions through an Organisation Committee and a Research Committee. The former consists solely of Council members, and acts as an executive body. The latter is a policy-creating body which advises the Council on such matters as priorities in relation to research programmes. The details of these programmes are in the hands of technical sub-committees, on which sit representatives from the industry generally, from Manchester and Liverpool Universities, Manchester College of Technology, and the Government. There are eight sub-committees. These are: Spinning; Sizing and Manufacturing; Finishing; Rayon; Silk; Physics and Testing; Chemistry; and, a recent addition, Technical Economy. They meet every six months under the chairmanship of the Director of Research. They are given an account of the work that has gone on, make recommendations, and then the various reports and recommendations are incorporated in the Director's annual report to the Council.

The Rayon Department was set up in 1927 because it was realised that research on problems in the cotton trade was very closely related to research on the problems concerned with the utilisation of rayon. During and since the second World War, there has been a movement to separate rayon from cotton. This is largely political, because up to the present, cotton, on the whole, has had a bad Press, and association with it has not been of any help. The position is changing today with the high export importance of cotton, which enables propagandists to give the industry a certain glamour. In fact, a separate Rayon Research Association has been set up. A director has been chosen, but the programme of work has not yet been outlined clearly. The Shirley has offered this new Association full facilities of co-operation, including the complete disclosure of all its own work.

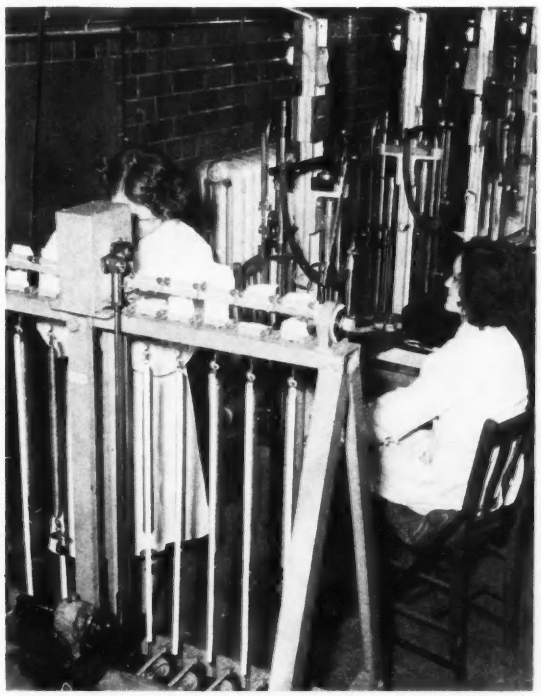
Having built up an organisation for research work on cotton, and having found that a large part of it was easily applicable to work on the chemical aspects of rayon, it was a very easy transition to take up work on natural silk, because the mechanical and physical problems relating to the working-up of silk were very similar to those of the working-up of rayon. There was, in fact, a distinct Silk Research Association formed after the first World War and centred on Leeds University; but it did not survive for long because it was not able to get sufficient individual subscriptions to earn the Government grant. BCIRA started a Silk Department in 1935. The Shirley deals—as Sir Robert Pickard put it—"with cotton from the fields almost to the wearer's back, with the utilisation of rayon after it is produced as thread, and with raw silk right up to the finished goods", and with any other fibres that may be presented for examination.

Internally, the Shirley Institute is divided into four main groups. These are: Physics, under Mr. G. E. Collins, employing about 70 persons; Mechanical Processing, under Mr. L. H. C. Tippett, employing about 120 in two departments—Spinning under Mr. F. Charnley and Weaving under Mr. J. J. Vincent; Chemistry under Dr. D. C. Clibbens, employing 16; and Chemical Processing, under Dr. R. C. Fargher, employing 40 in two departments—Technical Processing, under Mr. F. W. Thomas (concerned with the details of bleaching, dyeing, and finishing), and Chemical Analysis and Testing, under Dr. M. E. Probert. The Rayon Department, under Mr. W. A. Richardson, employs 26 persons; and the Silk Department, under Dr. F. O. Howitt, 14.

The various departments ancillary to the main organisation include: a Library and Information Bureau, under Dr. J. C. Withers, with a staff of five; an Engineering Department, under Mr. H. Hall, where about 100 employees can go ahead with work to the prototype stage; and a Liaison Department, under Mr. S. Taylor.

The Engineering Department has been built up in the past 10 years because of the emphasis on development work, especially on machinery development. Any ideas the Physics division may have about process machinery are investigated in the Meccano stage, and then go via the Instrument Workshop and the Engineering Department to the workrooms.

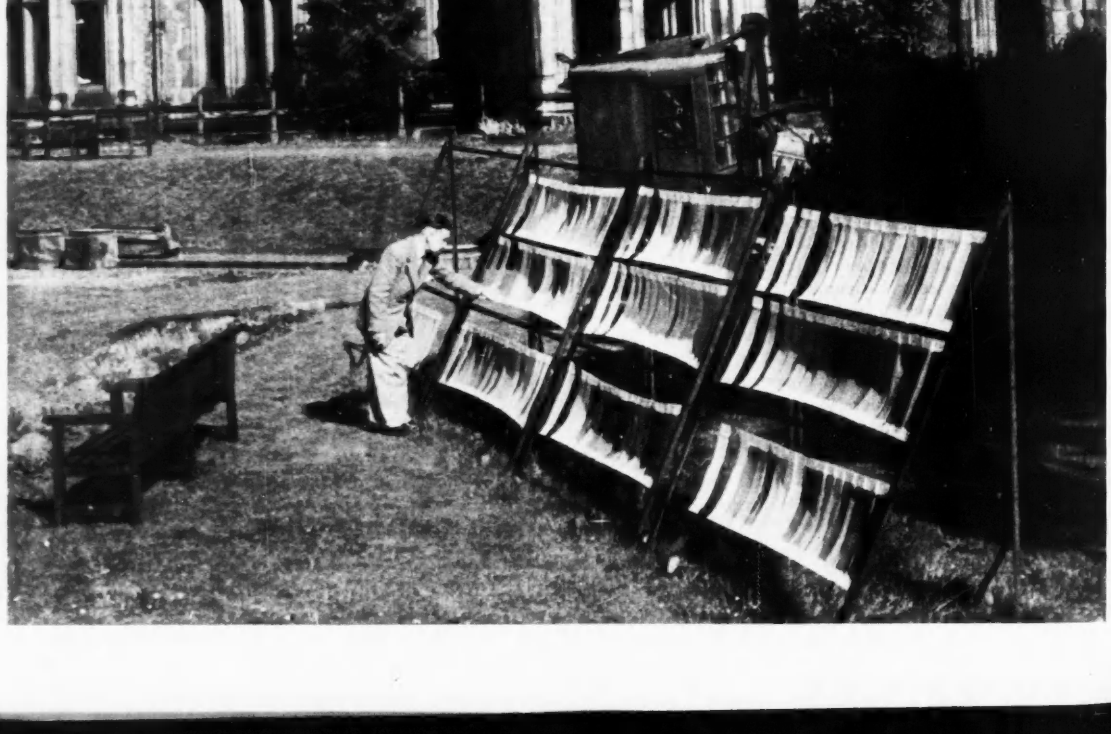
The Liaison Department is rather novel, and is connected with the attempt to put the fruits of research work over in the mills. It was obvious that it was not good enough to put results down on paper and leave it at that. Research had to be made understandable to the people carrying out the practical work. The Liaison Department consists of men with mill experience and technical qualifications who are competent to act, in a sense, as commercial travellers for the Institute. There are about twenty-four



Flexing and strength tests: a machine for repeated sharp flexing of fabric (foreground) and single-thread testers.

(*Above*) Stapling raw cotton.

(*Below*) Patterns of fabric exposed to weathering tests in connexion with rot-proofing experiments.



of these salesmen, and they spend part of their time in the laboratories finding out what is happening, and the rest of the time visiting mills. A good deal of their work is concerned with gaining the confidence of managers, for experience has shown that without that it is not possible to make a success of things.

The Director of Research appointed in 1943 is Dr. F. C. Toy, C.B.E., and the Deputy Director, Dr. D. W. Hill. There are two assistants to the Director, Mr. J. H. Black and Mr. G. W. Lobb, who is also Patents Officer. In all, the Institute employs some 500 persons, including about 100 graduates.

The main communication to member firms is the Institute Bulletin, which is published every two months. It contains at least one article of possible interest to each section of the trade. The articles are written by research workers, in straightforward language. They differ to some extent from papers in scientific journals, because laboratory proofs of the results stated are not always given and the articles often describe somewhat incomplete series of experiments—because the object is to get the co-operation of the mill at the earliest possible moment in the application of research results to mill processes. Confidential memoirs, which contain scientific results which appear to be capable of immediate application, are for circulation to members only. When declared 'open' they are reprinted in the *Journal of the Textile Institute*, or the journals of other learned societies. Papers dealing with the properties of materials are usually published openly, and those on technical processes are kept confidential.

There is also published every fortnight an Abstract Journal, containing an abstract of anything in science relating to textiles. For this summary of current literature about 200 periodicals from all over the world are taken. The Institute has also begun recently to give lectures to member firms on various aspects of research work, and its practical application.

The Physics Department does work, for example, in connexion with fibre testing, the physical properties of textile fibres and their relation to spinning processes, fibre damage, the physical properties of textiles, the soiling of textiles, the generation of static electricity and the tackling of static troubles in processing. There is a section which applies photographic techniques to particular problems; and another is investigating the construction of textile articles, for instance Dr. K. Weissenberg was working on stresses and strains in continuous materials.

The Chemistry Division is working, for instance, on chemically modified cellulose, the physical chemistry of dyes and dyeing, photo-chemistry, and the chemical constitution of starches. There is research on the problem of dust in card-rooms; on the general theory of drafting, that is, the theory of the process by which fibres are spun into yarn; and the physical properties of raw cottons, such as the correlation of fibre properties and spinning value.

In weaving, the electrical hygrometer, which makes an automatic process of moisture control, was developed by the Shirley and is now being produced commercially by John Dalglish and Sons, Glasgow. This machine is important because it allows of a 10 to 15 per cent increase in production. Warp yarn, before going to the loom, has to be specially treated by being dipped in a size of starch and fat to make sure that it will stand up to the shocks and abrasions in weaving.

It is dried to the correct degree of humidity to suit the weaving shed to which it is going. If the moisture condition is more than 9 per cent, the yarn is liable to become mildewed while stored. A worker known as a tape-sizer, by feeling the yarn between thumb and finger, checks that it comes off the sizing machine at the correct degree of moisture. He usually allows a safety factor of 2 or 3 per cent, so that the moisture condition is well below 9 per cent. The electrical hygrometer can measure the moisture condition highly accurately on a meter. It is now possible to control the moisture condition of a material sufficiently accurately and within limits fine enough to meet all practical demands. This means there is less wastage of yarn in storage due to under-drying, a great saving of fuel because the yarn is not over-dried, and an increase of production as the machine can now run faster without breaking the yarn.

Recently there has been set up a Chemical Engineering section to deal with problems of drying and calendering.

One of the outstanding achievements of the Shirley Institute was the discovery of Ventile Cloth, during the war. This arose because it was foreseen that we should be short of flax, essential for water-holding canvasses such as tanks, buckets, and fire hoses. Set with the problem of using cotton alone for these purposes, the Shirley scientists succeeded so well that hosepipes were made of cotton without any rubber. They were also able to make garment-weight fabrics in the same fashion. The clothes are watertight, not waterproof. This is achieved by using soft-twisted yarns with the maximum packing of threads. In contact with water the fibres swell, and close the interstices in the cloth so making a watertight fabric.

This Ventile Cloth was used for making immersion suits for convoy fighter pilots, and for naval outer garments

Part of the experimental card-room at the Cotton Research Association.

for use on arctic convoys. The cloth is especially suitable for hot climates, because as it is permeable to body vapours, the sweating caused by waterproofed raincoats is largely avoided.

During the past year there has been developed, under Mr. Tippett, a Technical Economy Section, which has been most intimately concerned with questions of productivity. He told a Directors' Managers' Conference, organised by the Recruitment and Training Department of the Cotton Board, at Buxton in October of last year: "Re-equipment has bulked large in the official policies for the industry, and in the long run, at least, it is essential. A few of the items of re-equipment can be arranged quickly and cheaply but most of them take time and require large capital resources to be available in the country and in the hands of individual firms. Since the policies were worked out, the economic position of the country (or rather the position as we appreciate it) has deteriorated badly, and the problems of the immediate future have become more urgent. The effects of re-equipment are slow, and can contribute little to overcoming the difficulties of the next one or two years; we are forced to look elsewhere."

The field which has been examined is that of increasing output through re-employment of labour without re-equipment. The recently published report on investigations started at Musgrave Mill by the Cotton Board is an example of this. But these experimental studies take a good deal of time: and so Tippett has been supplementing them with statistical investigations. (This is an interesting example of operational research as applied to peace-time industry.)

The Shirley Institute has conducted some "Abbreviated Surveys" of labour utilisation in about 100 spinning mills, selected by the Cotton Board more or less at random and covering all sections. Almost all the mills work on traditional Lancashire lines with traditional machinery and deployment. Yet productivity per man hour varies greatly between mills. "We then asked ourselves," says Tippett, why "can't everybody do as well as the best mills?" The variations were analysed and no fundamental technical reason could be found why one mill should be twice as good as another. Therefore, it was decided, technically it should be possible to bring all mills up to the practice of the best.

"We have calculated," says Tippett, "that if the operative hours per unit of production (OHP) for all mills in the coarse-medium count range could be reduced to the level of the average of the best one-quarter mills, roughly the following increases in output by the present labour force would result . . . giving an average for the whole spinning section in this count range of roughly 20 per cent."

Tippett's conclusions are now commonly accepted by all who are concerned with productivity—but all managements and workers do not find it easy to accept these new ideas. That is why Sir George Schuster is now engaged in a special study to determine how far all sections of the industry can be made to apply most speedily the short-term measures suggested by Tippett.

It is interesting to note that at the beginning of June, Mr. E. Thornton, secretary of the United Textile Factory Workers' Association, and a member of the Advisory Council of the Department of Scientific and Industrial Research, told the Textile Institute that he believed that the cotton textile trade unions were now more ready to consider the advance of science and its application to industry. He considered a weakness among trade unions was that they did not employ personnel who could keep abreast of scientific and technical development. The cotton trade unions, for instance, should have men trained in the field of time-study and work-load assessment.

Measurement of the flow of heat from the body and the resistance offered to it by clothing.

What of the future for BCIRA? Dr. Hill replied to me as follows: "This Institute is now doing so much work and the demands on it are so great that it is bound to expand by—I guess up to 50 per cent. Physically, the grounds and buildings now cover 21 acres, and the laboratories stand on 3 acres. The work itself, I think, will be of much the same character, but enhanced because there are various things of which only the seeds exist for the moment—as, for example, technical economy and chemical engineering. I look forward to the day when the results of our research work will be taken up more rapidly and extensively than now, and to the employment in the industry of more scientists who can appreciate the need for our doing more fundamental work."

Sir Harold Parkinson, the chairman of the Institute adds: "I would emphasise that Shirley works for the good of the whole and not of any one particular class. To improve the conditions of work for the work-people is every bit as necessary as to invent new machines and methods, fabrics or finishes, and commands equal priority on the time of our scientists. Surely, in Shirley we can all unite and work together in a common effort to restore our Textile Industry to its former glory—a glory which must be reflected not only in the restored prosperity of our nation, but in the individual happiness and contentment of every one of us, employee and employer alike, in our great industry."

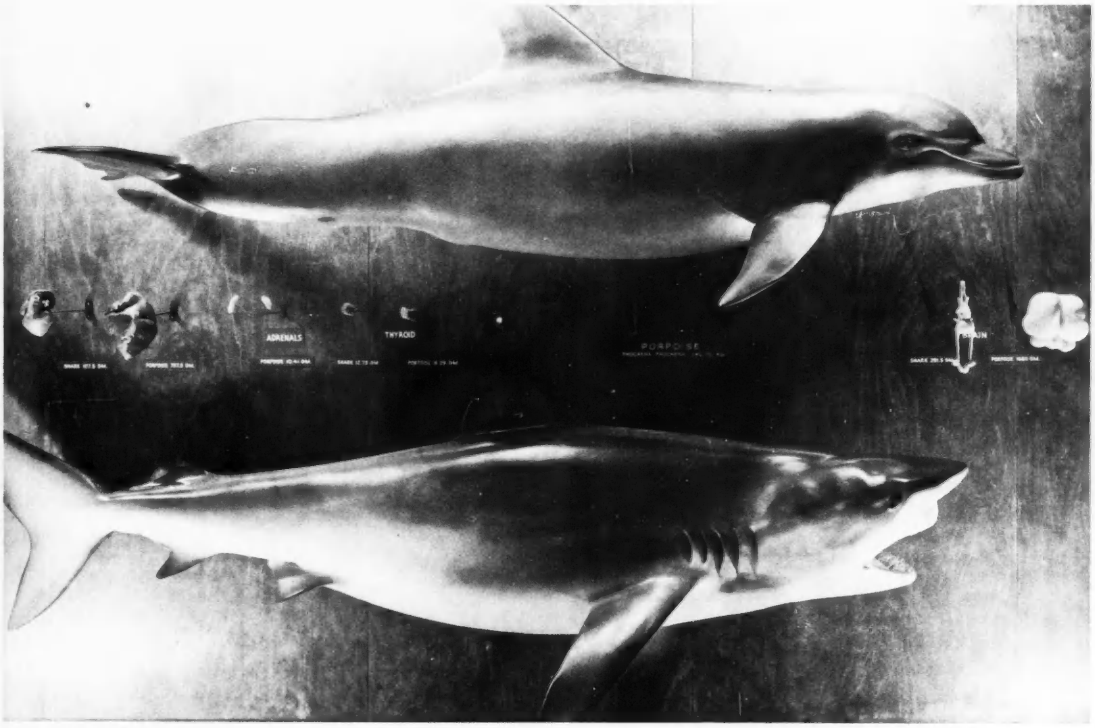


FIG. 1.—The porpoise and shark demonstrate that the energy system is affected by water cooling of the body surface. The warm-blooded porpoise must maintain a temperature of 98·5°F. and rises to the surface about once a minute to breathe. It requires a larger brain, thyroid and adrenal glands, and heart than the cold-blooded shark which takes its temperature from the surrounding water.

Gland Studies in Animals

THE PIONEER WORK OF DR. GEORGE CRILE

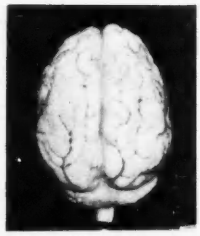
FRANK W. LANE

IT does not often happen today that a man makes a comparatively large area of knowledge peculiarly his own. Yet this may, with some justice, be claimed for the work carried out by the late Dr. George Crile of the Cleveland Clinic, Ohio, on the energy-controlling organs in man and animals. Not only did he amass a great deal of statistical information on the body weights of animals and their organs, but he also made a valuable contribution to our knowledge of the relationships between these organs and the animals' habitats and modes of life.

Dr. Crile was a surgeon, and he became impressed by man's peculiar susceptibility to various pathological disturbances affecting the nervous system and the endocrine glands, diseases which are generally unknown among other vertebrates, Most, if not all, of these diseases are related to the expenditure of energy. Dr. Crile believed, therefore, that it would be of value to make a comprehensive study of the energy-controlling organs in animals and to compare the data thus obtained with similar data on the same organs in human beings.

But here was a difficulty: many of the specimens obtained for dissection were domestic and zoo animals, and it was soon found that some of their organs were abnormal. In particular these 'tamed' animals suffered from enlarged thyroid glands. Dr. Crile realised, therefore, that if his investigation was to be continued satisfactorily it would be necessary to obtain a large and varied number of animals in normal health. Some such specimens were sent by various helpers, but the best way to obtain the large numbers required was to seek them in their native haunts.

Collecting trips were made in subtropical and temperate America, the subarctic regions, Guatemala and the Hawaiian Islands. But the most important expedition was to Africa where, in the vicinity of the great crater of Ngorongoro, there is probably a greater abundance and variety of animal life in a small area than anywhere else in the world. Altogether some 10,000 miles were covered in these expeditions. Eventually it was possible to tabulate the weights of the bodies, glands and other organs of nearly 4000 animals and men—from grasshopper to elephant,



BRAIN 440 gm.

THYROID 4·85 gm.

ADRENALS 8·93 gm.

FIG. 2.—The energy-controlling organs of the chimpanzee. Note the great brain development.

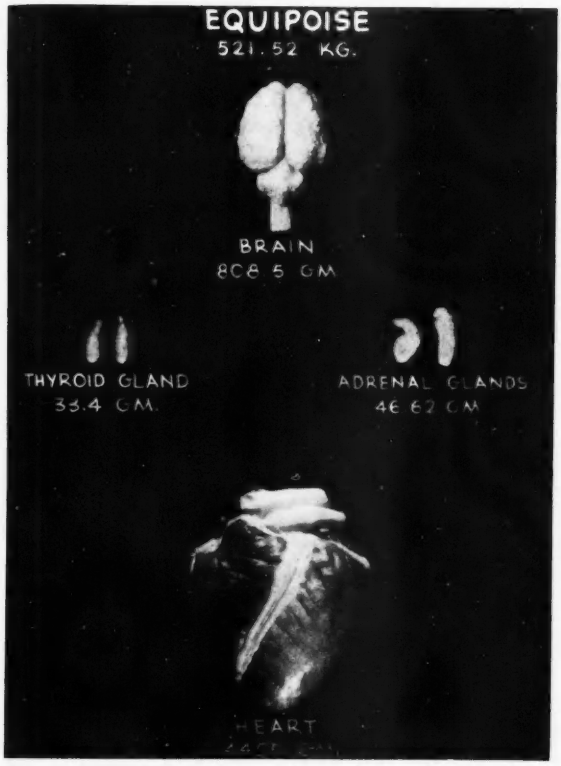
FIG. 3.—Comparison of eye weights. Python 1·12 gm., African Tawny Eagle 30·96 gm., Elephant 116·5 gm., Lemur 3·70 gm.

slug to sixty-ton finback whale. Over 20,000 specimens of tissues and organs were brought back to the Cleveland Clinic for detailed investigation.

The thoroughness with which the work was done may be gauged from the following description of the work in the Rift Valley, in Tanganyika:

> "In the field we weighed not only each of the 220 animals that we studied but also every organ of each animal and sometimes the skins and the skeletons. Some of the smaller animals were embalmed and sent back for dissection.
>
> Routinely, all animals except the largest were brought into our field laboratory, where they were weighed. The skin and every organ of the body were weighed separately. In all instances we collected the brain and pituitary gland, the eyes, the thyroid gland, the adrenal glands, the celiac ganglia and sympathetic complex, the heart, the kidneys, the lungs, the liver, the genitalia, often the spleen, and a section of the larynx and trachea. . . . In the case of the elephant it was necessary to weigh 176 different parcels in the course of the dissection in order to determine the entire weight of 14,640 pounds." An allowance of 5% was made for the blood.

Dr. Crile was chiefly interested in the brain, heart, thyroid and adrenal glands, all of which play a large part in controlling the expenditure of energy. It was the securing



of these organs from as large and varied a number of animals as possible which was the chief objective of the various expeditions.

The thyroid gland governs the level of constant energy. It controls the release of energy for the ordinary needs of daily life, such as digestion and heat production. It supplies the tireless, long-distance running energy of the timber-wolf and hunting-dog. It is the thyroid gland which enables the frightened deer or antelope to keep up the steady pace that often finally outdistances the pursuer. In these and similar pursuing and fleeing animals, the weight of the thyroid gland is only slightly below that of the adrenal glands. Incidentally, it is in man alone among land creatures that the thyroid outweighs the adrenals, the proportion being 2½ to 1.

The adrenal glands control emergency energy for the crises of life. They stimulate outburst or flash energy. By pouring adrenalin into the blood stream at the moment of danger they step up the whole organism to the point of highest physical efficiency. It is the adrenal glands which energise the cat-like mammals for their *blitzkrieg* attack on their prey, and it is the same glands which stimulate the predator's agile prey for their lightning-like dash for safety. Among these animals the adrenal glands considerably outweigh the thyroid.

It should be added that the pituitary gland is now regarded as exercising a regulating function over the activities of all the other endocrine glands, including the thyroid and adrenals. As it is sometimes expressed: "The pituitary is the leader of the endocrine orchestra."

FIG. 4.—Equipoise, a great thoroughbred race-horse. Its brain is the largest so far found in a horse. Compared with work-horses, the brains and hearts of race-horses are much more developed, though they may have less body weights.

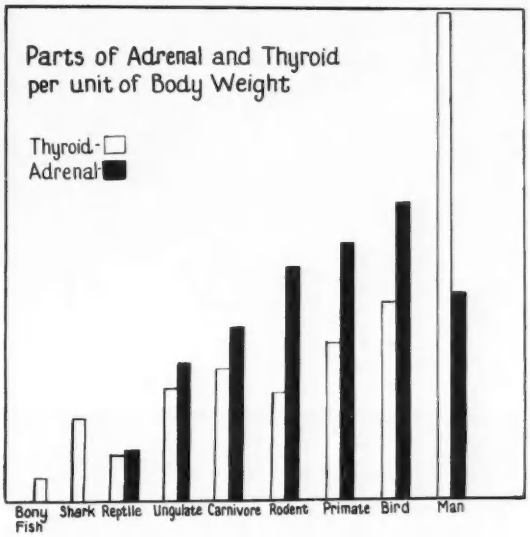
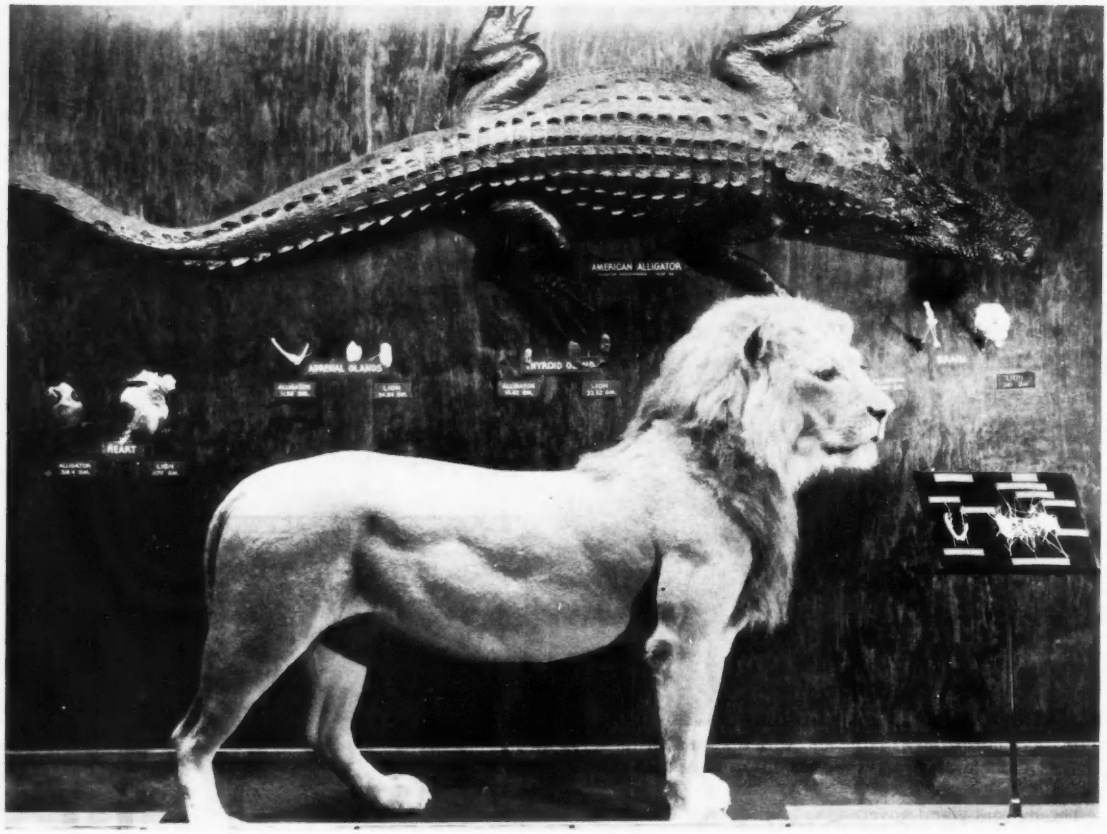


FIG. 5.—The thyroid-adrenal ratios for various orders of animals compared with man. The columns represent averages for various species. Man's thyroid gland is 2½ times the size of his adrenal glands. In other species adrenal predominance is the rule.

It is possible to run through the list of some 4000 animal weights and, with the functions of the thyroid and adrenal glands in mind, to obtain a fair idea of the type of life lived by various animals merely by noting the relative size of these glands. For example, in a flamingo, which lives a fairly placid life with an easy food supply, the thyroid gland weighs 0·27 grams and the adrenals 0·34, i.e. they are roughly of equal weight. But in the tawny eagle, which obtains its prey by swift and violent action, the relative figures are 0·12 and 0·35, i.e. the crisis glands are three times the weight of those necessary for constant energy.



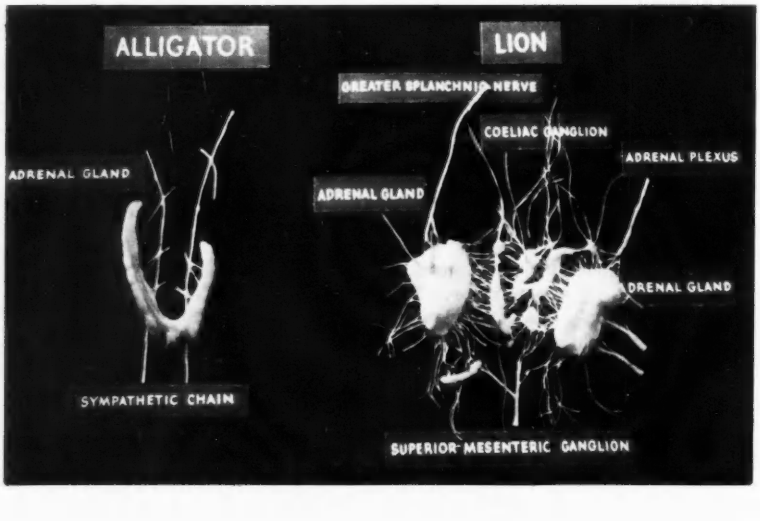
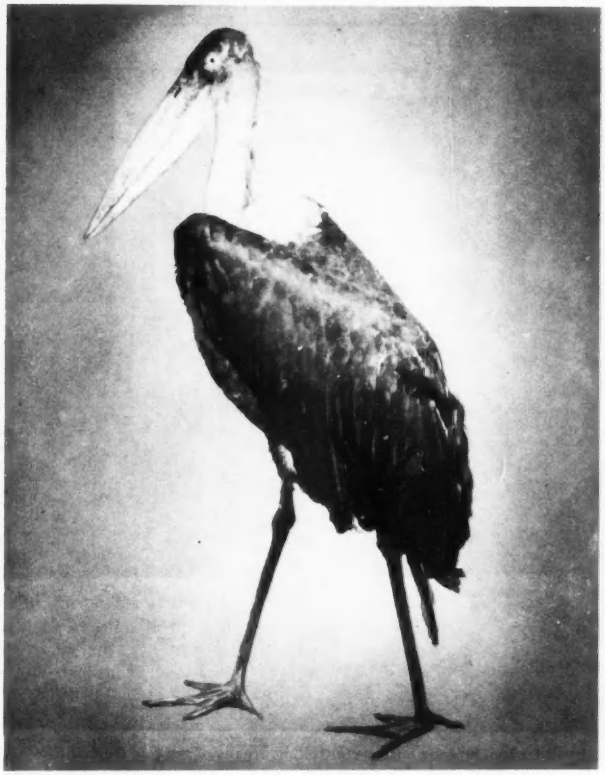
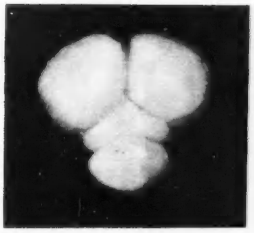
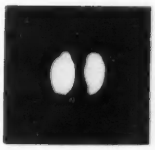


FIG. 6.—A comparison of the energy-releasing mechanisms of the lion and alligator. Skeleton and musculature are fairly equally developed, but the activity patterns differ enormously. The lion catches its prey with an explosive burst of energy—the alligator passively waits a chance victim. These differences are fully reflected in the size and development of the brain, glands, heart, etc. The coelic ganglion, which acts as an abdominal "brain" in mobilising energy exhibits greater complexity in the lion than in any other animal dissected.





BRAIN 30·27 gm.



THYROID 0·70 gm.

ADRENALS 2·80 gm.

FIG. 7.—The energy-controlling organs of the marabou stork. Comparable figures for a European stork show that adrenals and thyroid are approximately equal in weight. The reason for the difference is found in the life history of the two birds.

Again the sluggish crocodile has thyroid and adrenals which are approximately equal, but the puma or mountain lion has adrenals which weigh over four times those of the thyroid, indicative of the much greater need for releasing occasional outbursts of flash energy.

One of the most striking instances of the implication of the gland weight figures is provided by two birds of the same family. In the European stork thyroid and adrenals are approximately equal, but in the African marabou stork the adrenal glands are more than three times the weight of the thyroid.

Why should there be this notable difference between two birds of the same family? The solution is found in the life histories of the two birds. The European stork is a migratory bird, finding a good food supply at each end of its journey. It therefore needs sustained energy for its long migration flights, but has little need for crisis energy in securing its prey. Hence both glands are approximately equal in weight.

But the marabou stork is not a migratory bird, it often competes with vultures for its prey, flies strongly over moderate distances and has a much more belligerent temperament than its relatively placid European relative. Such life habits indicate a need for an ample supply of crisis energy, i.e. heavy adrenal glands.

In his book *Intelligence, Power and Personality* Dr. Crile has a chapter entitled "Elephant and Mouse" in which he compares the physical make-up and energy characteristics of these two widely different animals. The African elephant, which has practically no enemies apart from man, and whose normal life is one of the most placid in the animal kingdom, has thyroid and adrenals which are roughly of equal weight—1·89 and 2·07 lb. But the tiny African mouse, whose life is the epitome of insecurity and whose actions are often reminiscent of living quicksilver, has adrenal glands which are nine times as heavy as the thyroid—0·0095 to 0·001 grams. In fact the mouse is the most highly adrenalised animal known. The same difference is noted in the heart-beats of these two animals—28 beats per minute for the elephant against 300 for the mouse.

The dissection of the six-ton bull elephant provided some interesting data on the weights of the various parts of this huge animal. The skin alone weighed a ton, and the stomach and intestines with their contents weighed almost another ton. The lungs weighed 306 lb., the liver 235 lb., the genitalia 90 lb. and the kidneys 40 lb. The heart, which measured 51 in. in circumference, weighed 57½ lb. The trunk weighed 264 lb. and the entire head, including trunk and the huge six-foot ears, weighed 1399 lb.

The animal possessing the most fulminating energy

FIG. 8.—The massive head, weighing over half a ton, and the energy-controlling organs of the bull elephant.

known is the lion. It is even more powerfully endowed for *blitzkrieg* attack than the tiger. In two animals of comparable weight the adrenals of the lion weighed 34·64 against the tiger's 20·8 grams, and the comparative weights for the heart were 1175 against 698 grams.

A comparison between the adrenal-sympathetic complexes of the lion and alligator is illuminating. Whereas the lion has a maze of 82 pairs of nerve fibres in this complicated network, the alligator has but three. As Dr. Crile says: "No one could fail to see the difference in power that is generated by these two mechanisms."

What is the mechanism of the lion's charge? When a lion leaves the mark for the short explosive charge to its prey, there takes place within its body a physical change which is more akin to an explosion than to a bodily function. The large adrenal glands pour their crisis-energy-producing secretion into the blood and cause a greater discharge of the vitalising sugar from the liver to enrich the blood stream. The result of these chemical changes is that the lion's brain, heart, lungs and nerves are slammed into top gear, and its immense physical strength is concentrated in a violent outburst of energy which is expended in a few seconds.

These facts throw new light on the tremendous bounds of the lion, which have long been a source of wonder to men who have hunted the jungle king. Sir Alfred Pease, who shot more lions than most hunters, considered that when in full stride a lion in its prime could cover a hundred yards in three seconds. This is probably an exaggeration, but other observers have put the maximum speed of a charging lion in the region of 50 miles an hour.

Once the charging mechanism has been put in motion and the vital organs have been energised, nothing short of the most violent action *can* stop a lion. Even with its heart destroyed by a bullet a lion may continue to charge for a dangerous distance.

Dr. Crile discussed this question with Leslie Tarlton, a big-game hunter in Africa. Tarlton said that if an animal was quiet and not roused, a shot through the heart would drop it almost in its tracks, but if it was already alert when shot it might bound away or, if it were a lion, it might charge vigorously. It has been suggested to me, however, that a shot in a vital part of the nervous system might stop an animal effectively.

When a lion, whose bodily facilities are geared to such a high energy potential, is confined in a zoo where its food supply is assured and there is no occasion for it to use its explosive energy, its glands undergo considerable modification. The adrenal glands of a wild lion are roughly 25% heavier than those of a captive lion. In addition many captive lions suffer from goitre, and the heart degenerates.

(Acknowledgment is made to *Intelligence, Power and Personality* by Dr. George Crile, published in 1941 by the McGraw-Hill Book Company, Inc., for help in the preparation of this article. Some of the illustrations also appeared in this book.)

Life in the Ocean Depths

N. B. MARSHALL, M.A.

IN the last week of September the Swedish research ship *Albatross* docked in London on her way home after spending fifteen months at sea in world-wide investigations into the nature of the ocean floor and the overlying water masses. An illustrated account of the work of this Swedish expedition appeared in the November issue of DISCOVERY.

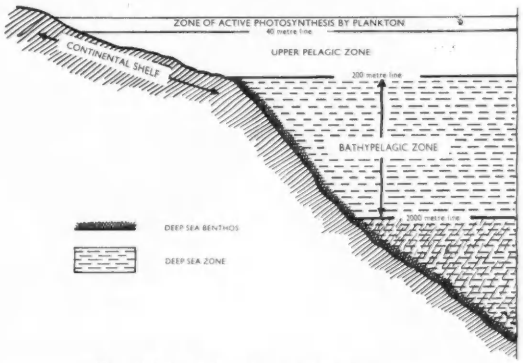
Exploration of the oceans is a strenuous, sometimes exciting and always costly business. Just how exciting it can be was shown in 1939, when a trawler operating off the Indian Ocean coast of South Africa caught the fish *Latimeria chalumnae*, a member of a group of fishes considered to have been extinct for about 50 million years.

With these recent events in mind a brief survey of our knowledge of deep-sea life (which began in earnest only 75 years ago with the voyage of the British research ship *Challenger*) seems apposite. Yet before this can be attempted it will be essential to describe the nature of the deep-sea environment, which has clearly caused extreme modification of the structure and physiology of the animal populations.

The deep sea begins at the edge of the continental shelf at a depth of about 200 metres, for here the continental slope begins to fall away more sharply to form the ocean basins. The striking features of these deep waters are the stillness (the currents are sluggish and may be practically non-existent), the coldness, the darkness and the high hydrostatic pressure. In descending from a level of 200 metres in tropical regions to about 1000 metres the temperature will fall from 15 -20 to about 5 C, while below 1000 metres the water will be near freezing. Light falling on the sea surface and penetrating is soon absorbed, the rays at the red end of the spectrum quickly, those of the blue end penetrating deepest and still being perceptible to the human eye down to about 500 metres. Finally, the hydrostatic pressure increases by about one ton per square inch for a descent of 1000 metres.

Although by far the greatest part of marine life, both in numbers and species, is found from the inter-tidal regions out to the edge of the continental shelf, the seemingly inhospitable depths of the sea support a great diversity of animal life. This may be sub-divided into *benthic* communities (living on or near to the sea floor) and *pelagic* (floating) communities. The latter are often termed *bathypelagic* and consist of organisms living roughly between 200 and 2000 metres; they range from the actively moving squids and fishes to slowly pulsating jellyfish.

Certain members of the benthic populations, particularly polychaete worms, molluscs and echinoderms, may also be found in the shore zones, but the majority are found in deep water and nowhere else. Prominent among these are siliceous hexactinellid sponges, sea pens and sea cucumbers of the order Elasipoda among the echinoderms. These animals, and many others, live and feed on the organic matter in the soft oozes of the sea floor or, by ciliary currents, catch the rain of dead plankton fragments which fall from the upper layers of the sea. Living close to the bottom, and no doubt feeding in part on this invertebrate life, are various fishes, notably the macrurids (related to the cod), the brotulids, fishes of the order Heteromi, and in arctic regions the liparid fishes.



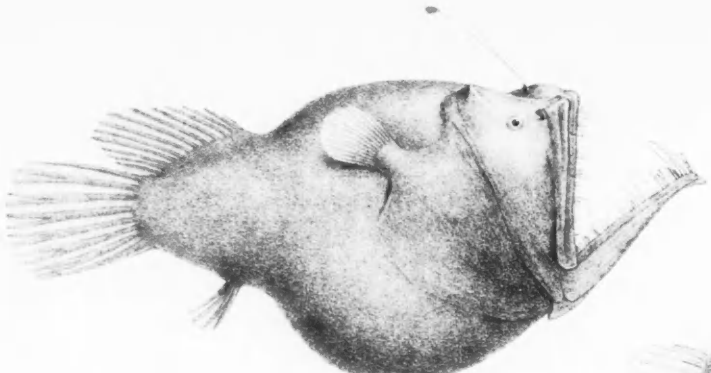
The divisions of the marine environment.

The bathypelagic organisms include many types of animals such as the Radiolaria among the Protozoa, various jellyfishes, nemertean worms; crustaceans such as copepods, amphipods and prawns; many cephalopod molluscs and an amazing diversity of fishes. Like the benthos, a high proportion of these animals are peculiar to the deep seas and again are ultimately dependent for food on the productive sunlit layers of the sea supporting the phytoplankton. Life in the depths of the oceans has been well summarised by G. L. Walls who says "Below 400 metres there are no days—only perpetual night. No plants can grow there, and so it is dog-eat-dog or dog-eat-carrion, for a considerable part of the food of deep-sea fishes consists of a rain of invertebrate corpses and vertebrate fragments drifting down to them from above."

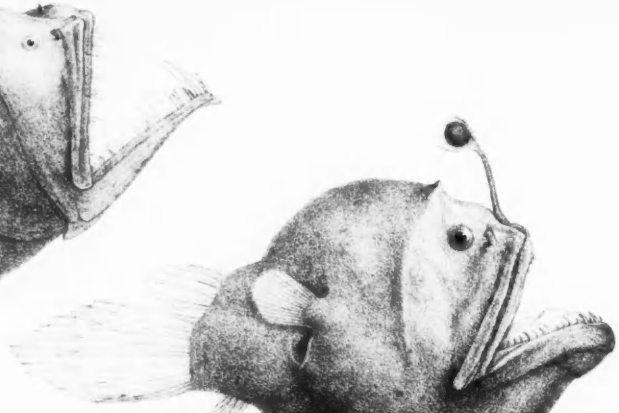
The great interest of these sparse populations of the deep seas is in the modifications of structure and physiology which have been produced through the interaction of organism and environment. The bathypelagic communities will best be considered first and will be discussed under the following headings; colour, luminescence, senses, air-filled structures, skeletal structure and reproductive modifications.

Colour

It is well known that blue and green colours are common in animals living near the surface of the sea, although many planktonic animals are hyaline or colourless. A descent to depths of 300 to 500 metres brings a striking change. Prominent here are silvery luminescent lantern fishes (Myctophidae), hatchet fishes (*Argyropelecus*) and stomiatoid fishes such as *Chauliodus*, while there is also a change to reddish or dark coloured organisms, such as the reddish prawns, arrow worms and certain copepods, or black or brown fishes (e.g. gonostomatids), pteropod molluscs and medusae such as *Atolla*. Deeper still in the lightless waters reddish or scarlet prawns are still found, but the fishes are all black or brown.



Melanocetus murrayi

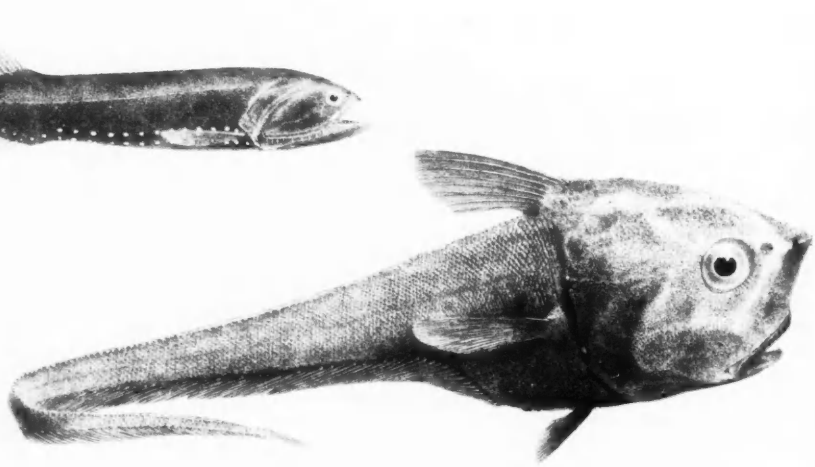


Ceratias bispinosus

Idiacanthus ferox

Ipnops murrayi

Gonostoma elongatum



Macrurus crassiceps

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What is the significance of these changes? The black of fishes living in darkness, although it would certainly seem to have a concealing value, is in great contrast to the pallor of fishes of caves. Certain organisms from the latter environment still retain the capacity of forming the black melanin pigments when exposed to light. Why should fishes living in the darkness of the seas be jet black? The question has now become quite baffling, but probably the answer lies in some undiscovered idiosyncrasy of melanin biochemistry which has no adaptive significance. Red colours, however, would seem to have a definite concealing value, for red rays are quickly absorbed in sea water. A red organism would thus appear black at a distance of a few yards and be difficult to spot in dim light. At depths where red light ceases to penetrate, the object would not, of course, appear red at all.

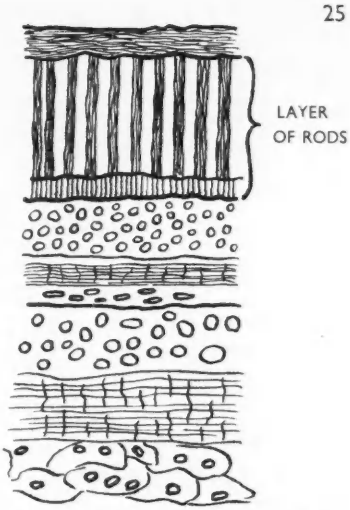
Luminescence

Animal luminescence is widespread in the deep sea, where it certainly reaches its highest development. Beebe estimates that roughly two thirds of the species of bathypelagic fishes (this includes about 97% of all individuals) are luminous. Apart from the fishes the most conspicuous luminescent organisms in the deeps are the prawns and euphausians among the Crustacea and the squids among the Mollusca. In the majority of these creatures the phosphorescent organs essentially consist of a cluster of light-producing cells faced with a lens to concentrate the light. Certainly in fishes, and probably in the other forms, the activities of these organs are integrated by nervous control.

In simpler forms of life the biological significance of luminescence seems quite obscure, but in the lives of the active and highly organised squids and fishes this biochemical lighting probably assumes greater importance. Beebe, who watched freshly caught lantern fishes, decided that the pattern of the photophores (or light organs) which is characteristic for each species, was an intraspecific recognition sign and enabling the fish to segregate into definite schools.

In certain of these fishes, and others, there is even a difference between the sexes in the arrangement of the photophores which no doubt assists in stimulating and bringing together the breeding individuals. It is of further interest that in a number of fishes, and definitely in one squid, *Lycoteuthis diadema*, different groups of photophores produce light of different colours, e.g. in *Lycoteuthis* the eye organs and the median ventral organ shine blue, the anterior organs ruby red and the lateral ones white. Whether this squid can perceive colour is unknown, but to anticipate a later section, the retina in deep-sea fishes is either entirely composed of rods, or the cones (the visual cells responsible for colour vision) are very few in number. More research is evidently required.

With this great development of luminescence is correlated the usually well-developed eyes of bathypelagic organisms (luminescence has not been evolved in cave faunas and associated with this the eyes have become much reduced). As already mentioned the retina in deep-sea fishes is practically entirely composed of rods, specialised cells which contain the visual purple or rhodopsin and are highly sensitive to light. Nocturnal animals have



Section of the retina of the deep-sea fish *Argyropelecus*.

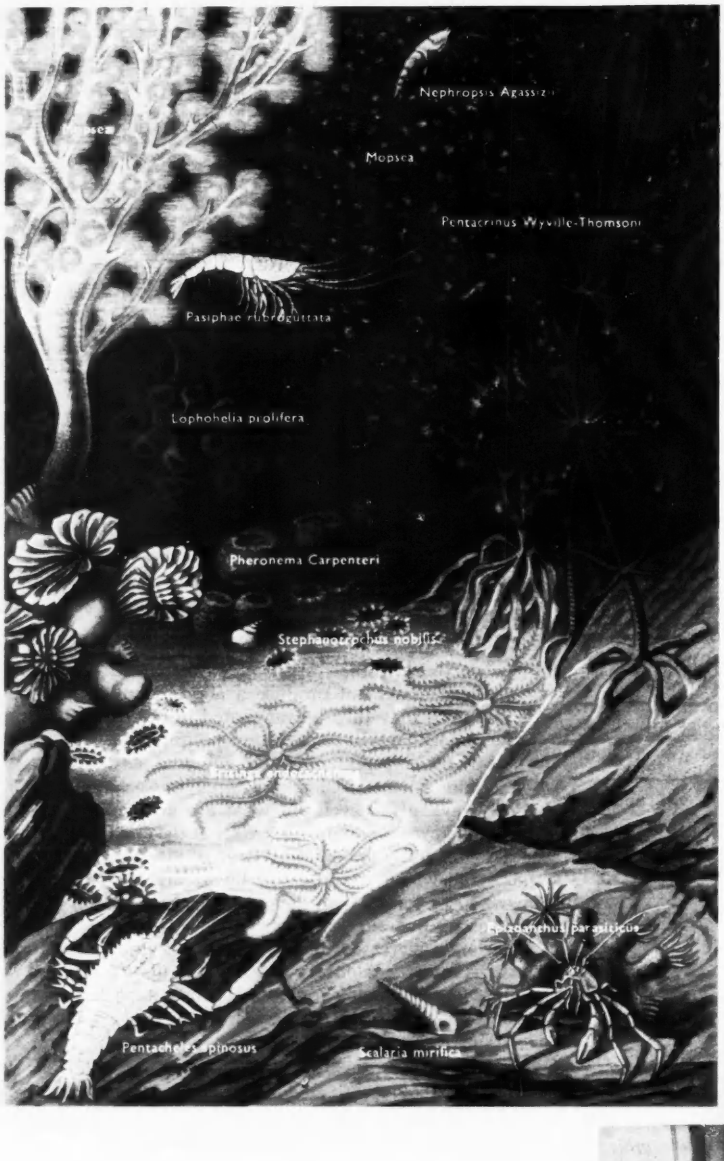
a rod-rich retina, but in these fishes sensitivity may be further increased:

(1) by an increase in the number of rods per unit retinal area;
(2) by the lengthening of the rods;
(3) by a greater number of rods feeding into one optic nerve fibre, the response from each rod (which by itself could not produce a nervous impulse to the brain) may thus be summated in the optic fibre to produce a well-remarked response;
(4) by the enlargement of the pupil and lens.

Certain of the squids, crustacea and a number of fishes have also developed what are erroneously called telescopic eyes, i.e. the eyes are set at the end of a tubular stalk. In the 'stylophthalmus' larva of the fish *Idiacanthus*, the stalk, which is supported by a cartilaginous rod, is many times longer than the eye-ball itself. By this means the base of the range-finding triangle between the two eyes is certainly increased, but when one remembers that this larva is only a temporary phase in the life history and is only a few millimetres long, this seems a doubtful advantage, particularly as the two ocular fields can have but little overlap.

Air-filled Structures

Hydrostatic pressures are enormous at great depths, but an organism living there needs no adjustment to counteract these effects, simply because the cells of the body are filled with a relatively incompressible medium whose pressure must at all times exactly equal that acting on the body surface. But a number of deep-sea fishes are known to possess an air bladder, an organ which by the secretion or absorption of oxygen from or into the blood, can vary the specific gravity of the fish in equilibrium with the external pressure. Probably, as Parr has pointed out, the air bladder is functionless at considerable depths since the energy required to attain equilibrium is so great as to be quite uneconomical. It is therefore interesting that in a number of deep-sea fishes the tissues of the air bladder have become highly reticulate and charged with fat, the latter being a light incompressible fluid, whose buoyant properties are therefore not impaired when subject to great pressures.



A group of deep-sea animals (from Filhol's *La Vie au fond des mers*, Paris, 1885).

Dr. O. Nybelin of the Gothenburg Natural History Museum holding a deep-sea macrurid collected by the *Albatross* expedition. Note its cod-like appearance.

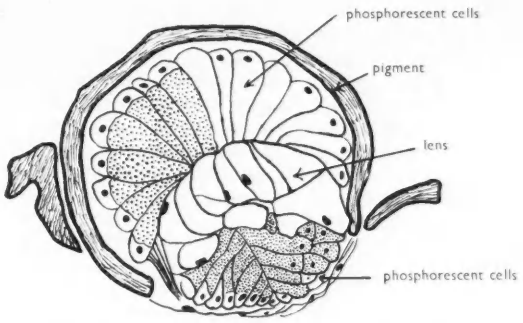
Skeletal Structures

The ossification or calcification of the skeletal structures of deep-sea animals such as fishes and the bottom-living echinoderms is much reduced. In the case of fishes, this had led to a certain amount of speculation. Roule first suggested that the skeletal features of a certain deep-sea fish (*Opisthoproctus*) had a rickety appearance. Vitamin D, which is synthesised by the microscopic green organisms in the upper sunlit layers is necessary in vertebrates for normal ossification of the skeleton. In the unlighted water below this there is the possibility that the vitamin decreases in amount and might, therefore, not be available in sufficient concentration for healthy skeletal development. Yet we have already mentioned that the rods which contain rhodopsin are highly developed in deep-sea fishes. Furthermore, it is known that vitamin A (also produced by the small green plants of the surface) is essential for the production of rhodopsin, this pigment partly or entirely endowing the rod with its high sensitivity to light. Deficiency of vitamin A in ourselves leads to poor night vision. If the same biochemical mechanism exists in fishes (and it is not unreasonable to assume it does) a shortage of vitamin A would greatly decrease their powers of perception of dim light, and thus nullify the striking adaptations of the eye already discussed. This seems so unlikely that it strongly suggests that vitamin A can exist or be obtained in sufficient concentration. Why should this not also apply to vitamin D? Perhaps we must look elsewhere for the factors causing the poorly ossified skeletons of deep-sea fishes.

Reproductive Modifications

In this dark environment, means must be found for bringing together the sexes at the breeding periods. In the ceratioid angler-fishes there exists a striking relationship between the sexes quite unparalleled in the vertebrates. Here the male, which is much smaller than the female, becomes attached to the body of the latter and is quite parasitic, the mouth region being fused to the skin of the female. Practically all the organs of these attached dwarf males are degenerate, except those of reproduction and circulation. The latter system is interesting in that the blood vessels of the head region of the male establish close contact with those in the skin of the female. By this means the male is nourished and is kept at hand for fertilising the eggs.

At about 2000 metres lies the lower limit of the bathypelagic zone. Between this level and the bottom exists a region where marine life becomes extremely sparse. On the bottom or closely associated with it exists another type of fauna, thinly distributed over the oozes and red clay of the ocean basins. It may be briefly considered in contrast to the bathypelagic fauna. The fishes are but rarely phosphorescent and many of them have much reduced eyes; one in fact, *Ipnops murrayi*, is the only vertebrate whose eyes have disappeared without trace. What is more remarkable is the development of phosphorescent areas where the eyes should be. In the present state of our knowledge this seems quite contrary to Darwinian concepts, for the only effect of this luminescence would be to make it visible to its enemies.



Section through the luminous organ, or photophore, of a deep-sea fish. A lens and luminescent cells are shown: in the retina there are long rods close together.

All five groups of the echinoderms—the sea lilies (stalked), sea urchins, brittle stars, starfishes and sea cucumbers—are found on the deep ocean floors. As already mentioned they have a poorly calcified skeleton, perhaps caused by the freezing cold and the intense hydrostatic pressures, the former being known to slow down the deposition of calcium carbonate and the latter probably causing this compound to be highly soluble and thus hard to precipitate in a skeletal matrix. The distribution of calcareous sponges from the shore to about 400 metres and their replacement at greater depths by siliceous sponges may well be caused by these limitations of calcium metabolism.

The density of life on the sea bed decreases the deeper the descent into the deep-sea environment. Food is no doubt the main limiting factor. There is, for example, more than a hint that the invertebrate populations living on red clay (which is the poorest of all deep-sea sediments in organic material) are extremely thinly distributed. As already mentioned, deep-sea communities are dependent for food on the rain of dead and decaying plankton organisms from the surface waters. The density of life on the bottom must, therefore, be particularly conditioned by the production of phytoplankton, the latter in turn depending on the availability of the nutrient nitrate and phosphate salts.

Data from the *Challenger* expedition is interesting here. At depths between 1800 and 3650 metres close to the shore an average of 121 specimens representing 39 species were taken; at comparable depths further from land these numbers fell to 21 specimens belonging to 10 species. These figures may be explained thus. Owing to the readily available supplies of nutrient salts, shallow inshore waters normally support a vigorous flowering of phytoplankton populations. As more of this production will find its way into the deep-sea environment closer inshore, it is understandable that these areas support a more numerous and diverse fauna.

It has not been possible to discuss here the ideas on the origin and evolution of the deep-sea fauna. Sewell Wright's theories on the rate of spread of mutations through populations being conditioned by the size of the latter could be interestingly applied if enough data were available. With recent improvements in technique, future research should throw much new light on these and related problems.

The Nobel Prize-winners

To Professor Patrick Maynard Stuart Blackett, the award of the Nobel Prize for Physics came almost as a birthday present, for he was born on November 18, 1897. He was educated and trained to be a regular officer of the Royal Navy at Osborne and Dartmouth Naval Colleges. He served with the Royal Navy throughout the 1914–18 war, and then proceeded to Magdalene College, Cambridge. to read science.

It was during the second World War, that Dr. C. H. Waddington, wrote, after mentioning Professor A. V. Hill's important position as Foreign Secretary of the Royal Society and a Member of Parliament, "But perhaps this (Hill's) position might be challenged, if we knew the facts, by one of the physicists on secret war work. There is, for instance, Blackett, educated as a Naval Officer and showing in his technical methods that combination of useful organisation and brilliant initiative, which the Navy seems to produce."

These qualities quickly received scope when, as a Cambridge graduate, he joined Lord Rutherford's unique atomic research teams at the Cavendish. Taking C. T. R. Wilson's well-known cloud chamber he made it automatic, and so took those half-million photographs, of which two or three visually confirmed Rutherford's deduction that the nitrogen nucleus was transformed by alpha-particle bombardment into other elements.

From the atom he switched his apparatus to the study of showers of cosmic rays. This apparatus enabled him to give conclusive proof of the existence of the positron, or positive electron, postulated by Dirac. Had Blackett been less conscientious about tying up loose ends and published his conclusions more swiftly, it is probable that he would have forestalled Anderson's announcement in California. Anderson made it two days before the publication of Blackett's precise paper, using photographs less convincing than Blackett's superb pictures to support his supposition.

In order to study the penetration of cosmic rays, Blackett established a cosmic ray station 100 ft. down at Holborn 'Underground' Station.

At Birkbeck College (where the only students are evening students, and hence the teaching staff have their days free for research) Blackett founded a very vigorous school of cosmic-ray research which continued to flourish after his departure for Manchester. (This school, now directed by Dr. George, has even succeeded in finding a use for London University's 'white elephant', the tower of the fine buildings in Malet Street; London's highest cosmic-ray research station is now perched at the top of this tower.)

Blackett remained at Birkbeck College from 1933 to 1937, when he was succeeded by another 'political physicist', Prof. J. D. Bernal. Blackett moved to Manchester as successor to Sir Lawrence Bragg in the Langworthy Chair of Physics.

When war began, Blackett turned his attention to naval and military affairs. In all three Services, and in all arms of the Services, he pioneered the use of the technique

known as 'operational research'. Blackett, and his team (affectionately known as 'Blackett's Circus') did great work, everywhere. During their time with A. A. Command, for instance, they helped to reduce the number of rounds needed to wing an enemy plane from 20,000 rounds to 4000. Tall, gaunt, lean-faced and terribly intense, Blackett put scientific method into military tactics and substituted calculus for 'gusts of emotion'.

Blackett's greatest war-time work was done at the Admiralty. In World War I he was an officer in the British submarine service; in World War II, Blackett did more than any other single person to defeat the U-boat. Our submarine counter-measures were designed by naval strategists following minutely the recommendations of Prof. Blackett and his colleagues, in particular Prof. E. J. Williams.

Blackett's interest in political matters is well known. His outlook is strongly marxist, and he stands very far to the Left; it is a mistake, however, to confuse him with the Communists and fellow travellers. It is hard to find a description that does him justice; perhaps one cannot do better than to say that he is a very advanced Fabian. He has never hid his political convictions. The broadcast he made in the famous B.B.C series on "The Frustration of Science" is still regarded as the 'reddest' science talk ever transmitted from Broadcasting House. During the Spanish Civil War he was one of the most effective organisers of aid for the Spanish Government.

The award of the Nobel Prize for Medicine to Dr. P. Müller recalls the remark of Lord Rutherford who, when he was awarded the Nobel Prize for Chemistry for research on radio-activity and atomic physics, said "It was the fastest transformation of a scientist I have ever known".

Dr. Müller gets the prize for his discovery of the insecticidal properties of DDT, a compound first prepared in 1874. This discovery was made in the Basle laboratories of Geigy, the Swiss dyestuffs firm. The insecticide, patented in 1939, proved very effective in use by Swiss farmers against the Colorado Beetle in 1940–1. It was introduced into Britain, America and Germany in 1942, and by the end of the war was widely used, in particular against the typhus-carrying louse.

His recent book (see DISCOVERY, November 1948, p. 352) on *The Military and Political Consequences of Atomic Energy* has aroused some little controversy and a great deal of amazement, for in it Blackett, the very same scientist who ousted 'gusts of emotion' from military affairs allows himself to be unreservedly and undisguisedly emotional about Russia and America; indeed in this work his flagrant and uncritical pro-Russianism goes so far as to out-Vishinsky the Stalinist case.

His keen sense of the social implications of science led him to become an early and ardent supporter of the Association of Scientific Workers, whose last president he was. As an A.Sc.W. representative he was the first science professor to attend the Trades Union Congress.

One cannot help feeling that something went wrong somewhere in his career. His present appointment does not match up to his great talents. Had he been less emphatic in expressing his political views, he might now perhaps fill with distinction the position that his teacher Rutherford occupied.

Coming late to science he has proved himself an artist in the design of ingenious apparatus. He has, too, the rarer gift of being able to direct others. At 51, an usually late age for making fundamental scientific discovery, he is organising a series of experiments on gravitation in coal mines, from which he hopes to obtain data to support his theory of magnetism of revolving bodies and its relationship with gravitation, a theory which has come under a bombardment almost as intense as his atomic energy book.

W. E. D., I. B. N. E.

Poet of this Scientific Age

T. S. ELIOT has been deeply impressed by the scientific age in which he has lived. Or perhaps it would be truer to say, quietly appalled by it. His own background is literary and religious. Scientific discovery holds no joys for him. The scientific age is for him a materialistic age growing more hideous and futile through war. His earlier poems—*Prufrock and Other Observations* (1917) and *The Waste Land* (1922) are a skilful reflection of that world.

Another poem of the same date *Mr. Eliot's Sunday Morning Service* opens with the word 'polyphiloprogenitive' to describe the bees outside the window. Later in the poem Eliot writes:

> *Along the garden-wall the bees*
> *With hairy bellies pass between*
> *The staminate and pistillate,*
> *Blest office of the epicene.*

A man in a café is described as 'The silent vertebrate in brown'.

(*Sweeney among the Nightingales*, 1920).

The Waste Land (1922), an intentionally obscure poem, pursued the same theme of society whose actions are only portraits of decay. In his notes on *The Waste Land*, Eliot says that not only the title but a good deal of the incidental symbolism of the poem were suggested by Miss Jessie L. Weston's book on the Grail Legend, *From Ritual to Romance*. Eliot adds: "To another work of anthropology I am indebted in general, one which has influenced our generation profoundly; I mean *The Golden Bough*; I have especially used the volumes Adonis, Attis, Osiris. Anyone who is acquainted with these works will immediately recognise in the poem certain references to vegetation ceremonies."

Ash Wednesday (1930) is the turning point in Eliot's poetical development. The sophisticated manner remains, but the cynicism is replaced by spiritual humility. This new attitude is re-echoed in *The Rock* (1934), a pageant play, whose choruses chant a condemnation of the modern, material, scientific world:

> *The endless cycle of idea and action,*
> *Endless invention, endless experiment,*
> *Brings knowledge of motion, but not of stillness;*
> *Knowledge of speech, but not of silence;*
> *Knowledge of words, and ignorance of the Word.*

All our knowledge brings us nearer to our ignorance,
All our ignorance brings us nearer to death,
But nearness to death no nearer to GOD.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
The cycles of heaven in twenty centuries
Bring us farther from GOD and nearer to the Dust.

The Word of the LORD came unto me, saying:
O miserable cities of designing men,
O wretched generation of enlightened men,
Betrayed in the mazes of your ingenuities,
Sold by the proceeds of your proper inventions.

And the wind shall say: 'Here are decent godless people:
Their only monument the asphalt road
And a thousand lost golf balls.'

O weariness of men who turn from GOD
To the grandeur of your mind and the glory of your action,
To arts and inventions and daring enterprises,
To schemes of human greatness thoroughly discredited,
Binding the earth and the water to your service,
Exploiting the seas and developing the mountains,
Dividing the stars into common and preferred,
Engaged in devising the perfect refrigerator,
Engaged in working out a rational morality,
Engaged in printing as many books as possible,
Plotting of happiness and flinging empty bottles,
Turning from your vacancy to fevered enthusiasm
For nation or race or what you call humanity;
Though you forget the way to the Temple,
There is one who remembers the way to your door:
Life you may evade, but Death you shall not.
You shall not deny the Stranger.

Eliot's most recent poems, the famous quartet—(*Burnt Norton*, *East Coker*, *The Dry Salvages*, and *Little Gidding*)—reveal him concerned not so much with the themes of this modern age, but rather with the timeless theme of man's longing for eternal life, for escape from time. Modern so-called civilisation, the life of the modern city, are evils comparable to death, over which man must somehow triumph by a kind of religious mysticism.

. . . . . They all go into the dark,
The vacant interstellar spaces, the vacant into the vacant:
The captains, merchant bankers, eminent men of letters,
The generous patrons of art, the statesmen and the rulers,
Distinguished Civil Servants, chairmen of many committees,
Industrial lords and petty contractors, all go into the dark
And dark the Sun and Moon, and the Almanach de Gotha
And the Stock Exchange Gazette, the Directory of Directors,

Professor Arne Tiselius, awarded this year's Nobel Prize for Chemistry, was born in 1902. Trained at Upsala University, he followed in his father's footsteps and became a scientist. He now holds a special Research Professorship at the Physico-Chemical Institute, Upsala, which enables him to devote all his attention to research. His electrophoresis apparatus has revolutionised protein studies; with it he separated the proteins in blood serum. This apparatus, as Dr. J. A. V. Butler points out in his recent Research *biography of Tiselius, finds extensive use in fields as far apart as clinical medicine and industrial chemistry. His recent lectures at London University made him famous in Britain; he is equally well known in America, where he researched (at Princeton) in 1934–5.*

And cold the sense and lost the motive of action,
And we all go with them, into the silent funeral,
Nobody's funeral, for there is no-one to bury.
I said to my soul, be still, and let the dark come upon you
Which shall be the darkness of God. As, in a theatre,
The lights are extinguished, for the scene to be changed
. . . .

. . . Or as, when an underground train, in the tube, stops too long between stations
And the conversation rises and slowly fades into silence
And you see behind every face the mental emptiness deepen
Leaving only the growing terror of nothing to think about.

Finally in *Notes towards the Definition of Culture*, a prose work just published by Faber and Faber, Mr. Eliot says:

"We can assert with some confidence that our own period is one of decline; that the standards of culture are lower than they were fifty years ago; and that the evidence of this decline is visible in every department of human activity."

The Bookshelf

Multiple-Beam Interferometry of Surfaces and Films. By S. Tolansky. (Oxford University Press, 1948, pp. 184, 113 figures, 18*s*.)

THIS is the first volume in a new series of monographs on the Physics and Chemistry of Materials, intended to summarise the applications of recent researches in materials and allied subjects. It presents, with much practical detail and enough theoretical explanation for those who are not optical specialists, an interesting account of new and important contributions to interferometry. As is rightly conceded, these are developments from the classical interference fringe systems of Newton, Talbot, Fizeau, Haidinger, Hamy, Fabry and Perot.

The basis is the proper use of multiple-beam interference phenomena obtained, both by transmission and reflexion in appropriate conditions of illumination, from highly reflecting silver films deposited by the modern vacuum evaporation method on the surfaces to be studied. Minutest details of crystal surface topography, particularly of mica, can be elucidated, as well as the optical properties of thin metallic films. Of interest to metallurgists and precision engineers are the applications of the reflected white light fringes to the study of polished, lapped or etched metal surfaces, and a plastic replica method for a similar purpose is also described. The principles and manufacture of interferometric colour filters are outlined and might be used for studying monomolecular layers. Nearly 100 well-reproduced interferograms amply justify the claims made for a resolving power approaching 5 Angstroms for certain crystal lattice spacings, and that the simple, elegant methods described compare favourably for some purposes with the electron microscope.

H. BARRELL.

Oceanic Birds of South America. By Robert Cushman Murphy, 2 volumes. (Macmillan, New York, pp. 1245, £4 7*s*. 6*d*.)

THIS is the standard work on its subject, sub-titled "a study of species of the related coasts and seas, including the American quadrant of Antarctica, based upon the Brewster-Sanford Collection in the American Museum of Natural History", and was first published in the United States twelve years ago. In more than 1200 pages, admirably illustrated by 80 text-figures, 72 photographic and 16 coloured plates, the sea-birds of the Atlantic and Pacific coasts of South America are considered in sufficient detail to satisfy all ordinary workers in the groups concerned. These groups comprise the penguins, albatrosses, petrels, tropic-birds, pelicans, boobies, cormorants, skuas, jaegers, gulls, terns and skimmers, together with a few representatives of the ducks, geese and waders. Ornithologists familiar only with the North Atlantic will probably at once have picked on the omission of the auks from this list, and may be surprised to learn that they do not occur anywhere on the coasts of South America. One-quarter of the monograph is devoted to the geographical and hydrological background.

R. S. R. FITTER.

Powder Metallurgy. By Dr. Paul Schwarzkopf. (Macmillan, New York and London, 1947; pp. 379, 40*s*.)

DR. SCHWARZKOPF'S thirty years of work in research and practice in the powder metallurgy industry has been, to a considerable extent, responsible for the present development of that industry. He now feels it timely to put at the service of the coming generation of metallurgists the results and reflections of a life's work, still far from completed. His book is divided into four sections, dealing respectively with Processes, Products, Theoretical Principles, and Future Developments, each has its bibliography complete to 1946, and may be said amply to fulfil the author's intentions. The strength of the book lies in his clear conception of the fundamental principles involved in the preparation, compacting and sintering of metal powders which are never far out of sight even in his discussion of practical processes; so that while strictly theoretical treatment only occupies one-tenth of the book, its influence is felt throughout.

This issue of DISCOVERY contains a title-page and index for Volume IX. Orders for binding cases for Volume IX can now be accepted for delivery next month, price 4*s*. *post free. We shall be pleased to bind readers' copies, supplying index, title-page and binding case, at an inclusive charge of* 9*s*. 6*d*. *Bound volumes for* 1948 *are also available, Price* 30*s*.

This attitude on the part of the author makes the book, which is by all counts a most comprehensive study of all aspects of the subject, valuable both to the practical powder metallurgist and the research worker.

P. SAVILLE.

Horology. By J. Eric Haswell. Reprinted. (Chapman & Hall, London, 1947; pp. 288, 16*s*.)

THE reprint of this book will be welcome to all students of the subject, for it contains much useful information. It is a matter of regret, however, that no attempt has been made, either to correct some of the erroneous details concerning the history of early clocks, or to survey the most recent advances in methods of time measurement. Except for a supplement, which was added in 1937, the book is identical with the first edition, published in 1928, and many developments have taken place since then.

The book makes no mention of the quartz crystal clock, or of the synchronous electric type of clock, omits any description of the latest models of the more familiar types of domestic clock, and is very much out of date in its comments on tower clocks. With such omissions, the work can hardly claim to cover the field of horology in a satisfactory manner, for all technical books need periodic revisions and additions, a task that is certainly overdue in this case. Altogether, the book is very good. Only its out-of-date sections prevent it from being excellent.

Vision and the Eye. By M. H. Pirenne. (*Frontiers of Science Series*, The Pilot Press, London, 1948; pp. 187, 12*s*. 6*d*.)

DR. PIRENNE has a fascinating story to tell in this book. He is concerned with the integration of the physiological data on the construction and organisation of the eye with the physicist's knowledge of how it behaves as a detector of light; a problem which has not been satisfactorily solved at any level, popular or advanced. As a worker in the field, however, he is not afraid to point out the difficulties and to show where further experiments are necessary before understanding is complete.

One of the most interesting points about this subject is the way in which facts about the eyes of birds, beasts, and insects have been shown by the physicists to fit into a single pattern. Few would have imagined, for instance, that it would be possible to measure the sensitivity of the eye of an owl to light of different wavelengths (a determination which is far from simple for a human being), or the visual acuity, that is the size of the smallest distinguishable detail, of a bee. Dr. Pirenne explains clearly both how these measurements were made and the significance of the results.

In a book of this size it is impossible to deal exhaustively with the subject, and the author's selection clearly indicates his own interests. The relation of the ultimate sensitivity of the eye to the quantum of light and the related problem of visual acuity at very low intensities are dealt with at some length. There is an excellent introduction to the physiology of the retina and its connexions with the brain. The section on colour vision attempts rather too much in the space available and will prove difficult to the lay reader, but this is the only weak part of the book. As a whole it can be strongly recommended.

The author and publishers are to be congratulated on the excellence of the illustrations, many of which are reproductions of engravings from works dating back to the seventeenth century. Besides conveying the essential information these are a delight to the eye. On the other hand, very much better use could have been made of the small section of colour plates. Finally, the reviewer would like to enter a strong protest against the practice of mixing bibliography and notes at the end of each chapter.

C. G. A. H.

A Second Resignation from the Soviet Academy

To the President of the Soviet Academy of Sciences.

I have come to the conclusion that I ought to resign the Honorary Membership of the Academy of Sciences of the U.S.S.R., to which I was elected in May, 1942.

When your distinguished predecessor, Academician V. L. Komarov, wrote to inform me of the honour thus conferred upon me, his letter made reference to the fact that I was then President of the Royal Society of London. I believe that many British scientists, indeed, recognised and welcomed my election at that time as the symbol of a community of purpose between the scientists of our two nations, which had then been engaged together for nearly a year in the war against Hitler's Germany—in defending, as we believed, the freedom of Science, as of all man's proper activities, from the threat of an aggressive tyranny.

In that same year, 1942, the Royal Society of London elected Nicholas Ivanovitch Vavilov to be one of its fifty Foreign Members. With Lenin's support and encouragement he had been able, as first Director of the Lenin Academy of Genetics, to initiate and promote a rapidly growing contribution, by research in the U.S.S.R., to that world-wide advance in the science of Genetics which had followed the recognition of Mendel's discoveries. His use of these opportunities was reputed to have been of great benefit to Agriculture in the Soviet Union; we desired to honour it as a great contribution to Science for the whole world.

It had been reported in Britain, however, already in 1942, that N.I. Vavilov had somehow fallen from favour with those who came after Lenin, though the cause of his trouble was still unknown; we might have supposed it to be political, or otherwise irrelevant to his scientific achievement. Not till 1945 did the Royal Society discover that he had been dismissed from his position, had disappeared with a number of his co-workers in Genetics, and had died at some unknown date between 1941 and 1943. Repeated enquiries, addressed to your Academy by the Royal Society through all available channels, asking only the date and the place of his death, received no reply of any kind. I understand that the Royal Society has not yet been officially informed whether this distinguished Russian scientist was still alive at the time of his election to its Foreign Membership.

More recent events, of which full reports have come to hand, have made it clear what has happened. The late N.I. Vavilov had been replaced by T. D. Lysenko, the advocate of a doctrine of evolution which, in effect, denies all the progress made by research in that field since Lamarck's speculations appeared early in the nineteenth century. Though Darwin's work is still formally acknowledged in the U.S.S.R., his essential discovery is now to be rejected there. The whole great fabric of exact knowledge, still growing at the hands of those who have followed Mendel, Bateson and Morgan, is to be repudiated and denounced; and the last few, who were still contributing to it in the U.S.S.R., have now been deprived of position and opportunity.

This is not the result of an honest and open conflict of scientific opinions; Lysenko's own claim and statements make it clear that his dogma has been established and enforced by the Central Committee of the Communist Party, as conforming to the political philosophy of Marx and Lenin. Many of us, Mr. President, have been proud to think that there were no political frontiers or national varieties in a Science common to all the world; but this is now to be separated from 'Soviet Science' and repudiated as 'bourgeois' and 'capitalistic'.

Decrees which the Presidium of your Academy has issued, on August 27th of this year, give effect only too clearly to this political tyranny. My old and honoured friend, Academician L. Orbeli, distinguished neurophysiologist of the school of your great Pavlov, is dismissed from his Secretaryship of your Academy's Department of Biological Sciences, because he has failed to anticipate your Decrees, in their restriction of all research and teaching in Genetics in the U.S.S.R. to this politically imposed orthodoxy. It remains to be seen whether such compliance with dogma is to be exacted in other departments of Science. So far we know only that the Genetics encouraged by Lenin is now prohibited as alien to his political philosophy.

Since Galileo was driven by threats to his historic denial, there have been many attempts to suppress or to mutilate scientific truth in the interests of some extraneous creed, but none has had a lasting success; Hitler's was the most recent failure. Believing, Mr. President, that you and your colleagues must be acting under a like coercion, I can only offer you my respectful sympathy. For my own part, being free to choose, I believe that I should do disservice even to my scientific colleagues in the U.S.S.R., if I were to retain an association in which I might appear to condone the actions by which your Academy, under whatever compulsion, is now responsible for such a terrible injury to the freedom and the integrity of Science.

With deep regret, I must ask you to accept my resignation.—Yours faithfully,

HENRY H. DALE.

London, 22nd November, 1948.

(Sir Henry Dale, late president of the Royal Society, is the second Nobel Prize-winner to resign over this controversy.)

Letter to the Editor

SIR,

Perhaps you will allow me to add something to the Russian genetics controversy. In 1933 I spent several months in the Soviet Union and visited many of the Experiment Stations and Research Institutes of that country in company with N. I. Vavilov. I saw Lysenko in Odessa catechised him for several hours and inspected his practical work. It was quite clear that Lysenko was blazingly ignorant of the elementary principles of both plant physiology and genetics, and that he was just a biological circle-squaring Ukrainian peasant—capable of fooling politicians, but not scientists. You simply couldn't talk to Lysenko—it was like discussing the differential calculus with a man who did not know his 12-times table. When I say that some of his assistants were using plant pots without drainage holes, your amateur gardening readers will understand.

After much persuasion Lysenko gave me a formula for vernalising cotton seed. After giving the method a full trial, we found that it just didn't work.

Many of the results that he and his collaborators obtained later are plainly faked, and it is pretty clear that the substitution of the Lysenko-Michurin methods for the accepted technology of applied genetics has put back the Soviet Union into the bow-and-arrow category so far as world science is concerned.

The root of the trouble is this. We are floundering in a new sort of world in which we must leave many things to experts. Who is to choose the expert, and how do you know that he is an authentic specimen when you have got him? In many cases the expert is chosen because he shouts *I am an expert* so loudly and convincingly that the poor simple politician believes him, and puts him in a position of great authority. The real experts are known only to a small coterie of their fellow workers, and are unknown either to the politician or to the general public.

The fact is that you can go on talking nonsense for years about biology without getting found out, and you can even promise miracles to the politician and get away with it, as Lysenko has done. In mathematics it is somewhat different, for 2 and 2 still make 4 both in our own bourgeois science and in that of the Soviet Union. That seems to be about the only point on which our two sorts of science still agree.

Lamentable it is to see the once brilliant Academy of Sciences of the U.S.S.R. become a pseudo-scientific Dotheboys Hall with Trofim Lysenko cracking his whip and playing the part of Wackford Squeers.

Yours, etc.,

S. C. HARLAND

(Dr. Harland, F.R.S., is of course one of the world's foremost authorities on applied genetics, and a specialist in cotton breeding).

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Henry Deacon

was an Englishman who, in 1868, found a new method of obtaining chlorine from hydrochloric acid gas, at that time a by-product of alkali manufacture. His method, known as the "Deacon Process" was eventually used all over the world. Side by side with another process, also invented by an English chemist, Deacon's invention made possible the commercial production of chlorine. This important heavy chemical is used in bleaching, for the manufacture of disinfectants, cleaning fluids and industrial solvents. Municipalities employ it for sterilising water supplies. Chlorine and its derivatives are essential to the chemical engineering and textile industries. Deacon was born in London in 1822. His parents were extremely poor, but they were fortunate in enjoying the friendship of Michael Faraday. The great scientist took upon himself the supervision of the boy's brief education at a Quaker school in Tottenham. He left at the age of 14, and was apprenticed to an engineering firm, but soon afterwards it went bankrupt. He then moved to Lancashire, having his indentures transferred to Nasmyth and Gaskell, but at the age of 26 forsook engineering to become manager of Pilkington Brothers' glass-works at St. Helens. He abandoned glass a few years later when offered the managership of a small alkali works at Widnes. Subsequently he set up works of his own in partnership with William Pilkington and later with Gaskell — his former employers. He died of typhoid at the comparatively early age of 54.

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